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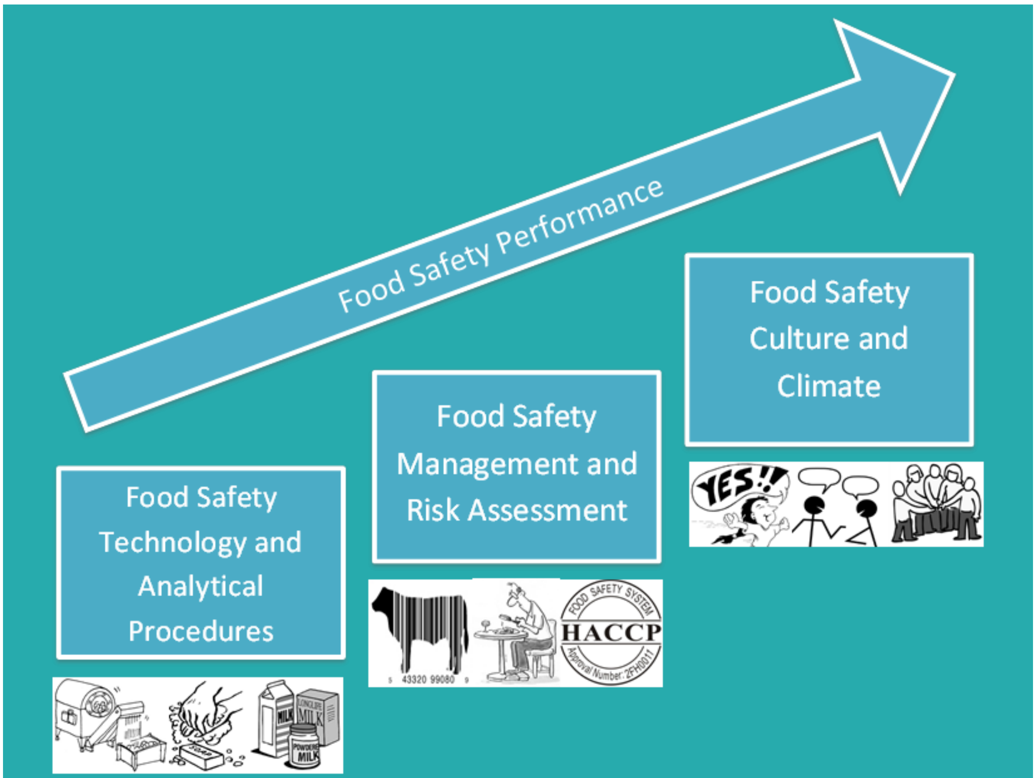

Food Safety Culture and Climate, Exploring the Human Factor in Food Safety Management

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Food Safety Culture and Climate,

Exploring the Human Factor in Food Safety Management

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Dutch translation of the title:

Voedselveiligheidscultuur en -klimaat, onderzoek van de menselijke factor in een voedselveiligheidsbeheersysteem.

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Elien *Geraardsbergen, mei 2018*

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List of Abbreviations

AFNOR	Association Française de Normalisation
ALOA	Agar Listeria according to Ottaviani and Agosti
ANOVA	Analysis of variance
B2C	Business-to-consumer
BPW	Buffered Peptone Water
CAC	Codex Alimentarius Commission
CCP	Critical Control Point
CDC	Centers for Disease Control and Prevention
CFU	Colony Forming Units
CI	Confidence Intervals
CP	Control Point
EC	European Commission
ECDC	European Center of Disease Prevention and Control
EFSA	European Food Safety Authority
EHEC	Enterohemorrhagic *E. coli*
EU	European Union
FAO	Food and Agriculture Association
FASFC	Federal Agency for Safety in the Food Chain
FAVV	Federaal Agentschap voor de Veiligheid van de Voedselketen
FBO	Food Business Operator
FEVIA	Federatie van de Belgische Voedingsindustrie (Belgian Association of the Food Industry)
FMFP	Research unit of Food Microbiology and Food Preservation
FSA	Food Standards Agency
FSMS	Food Safety Management System
FTE	Full-time equivalents
GMP	Good Manufacturing Practice
HACCP	Hazard Analysis and Critical Control Points
ISO	International Organization for Standardization
IT	Inforamtion Technology
KPI	Key Performance Indicator
LMX	Leader-member exchange
log	Logarithm (base 10)
MANCP	Multi-Annual Control Plan

MCAR	Missing Completely at Random
MRSA	Methicillin-resistant *Staphylococcus aureus*
PCR	Polymerase chain reaction
PRP	Prerequisite program
qPCR	Quantitative PCR
RTE	Ready-to-eat
SE	Standard Error
SMEs	Small and medium-sized enterprises
STEC	Shiga toxin producing *Escherichia coli*
UGent	Ghent University
UK	United Kingdom
US	United States of America
VRBG	Violet Red Bile Glucose
WHO	World Health Organization
XLD	Xylose Lysine Deoxycholate

Objectives and outline

By the introduction of the Codex Alimentarius 'General Principles of Food Hygiene' (CAC, 2003) and enforcement via the General Food law (Regulation (EC) No 178/2002) European food companies were forced to make changes in their food safety management system to favor and control food hygiene and food safety in a more performant and preventive manner. Together with EU Regulations 852/2004 and 853/2004 the foundations were laid down for a holistic system of prevention, preparedness and own-check activities to control and assure food safety and hygiene in a food business, i.e. the food safety management system. As such, food companies in Europe are obliged to develop, implement and maintain a food safety management system, which was a major challenge for many companies in the last decade. However, making the balance, even if well-elaborated food safety management systems are in place, an always high and stable level of hygiene and food safety cannot be guaranteed, as despite these efforts, consumer food poisoning and foodborne outbreaks still occur. In many of these cases, human behavior and personal characteristics of employees (and consumers) could be an important cause in these foodborne outbreaks. Consequently, human behavior may determine whether or not food safety and hygiene procedures are followed and appropriate decisions are made. This human behavior may be influenced by the prevailing food safety culture or climate in the organization, introducing the human factor in food safety management, which is the focus of the current PhD thesis.

The overall objective of the current manuscript was to 'explore the human factor in food safety management by studying the impact of an organization's food safety culture and climate'. The manuscript is divided into seven chapters, each of the chapters contributing to the exploration of food safety culture/climate and its role related to food safety management (Figure 0.1).

In **chapter 1**, different aspects of the food safety management system and its performance are explained as introduction. Also, the impact of human behavior in food industry is investigated through a literature review. Before discussing 'food' safety culture and climate, organizational culture and climate are studied, and via a section about safety culture and climate, **chapter 1** eventually finishes with a section on 'food safety culture and climate', proposing definitions and a framework which will be used and built upon throughout the whole manuscript.

Several authors (e.g. Cooper and Kleinschmidt (1995); Maximova (2015)) acknowledge the fact that measurement and analysis of performance are of key importance, separating successful organizations from unsuccessful ones. An approach more commonly known as 'Measure what you treasure' (Bouwman, 2016). As such, a first specific objective in the exploration of food safety climate/culture is 'the development and validation of a tool to measure food safety climate in food companies'. This was achieved in **chapter 2**. In this chapter a food safety climate self-assessment tool was developed and validated by experts. Also a pilot study was performed to test the tool in practice. This tool is then used throughout the research for the assessment of food safety climate in food companies.

Food companies are, of course, interested in what food safety culture and climate might mean for their organization, as such, in a first phase, food safety culture and climate will be studied at the level of the organization. The second specific objective is therefore to 'study food safety climate and culture at an organizational level'. For this objective, we will not focus on the individual employees, but look at food safety climate and culture in the organization as a whole. This was investigated in **chapters 3, 4 and 5**.

As the entity under investigation within the second objective of this doctoral dissertation is 'the organization' and as it has been proven that several organizational characteristics can impact the performance of a food safety management system (e.g. Jacxsens et al. (2015)), it would be interesting to unravel whether and how certain organizational characteristics influence food safety culture and climate in food companies.

Therefore, the potential impact and relationship of company size and structure on food safety culture and climate was investigated. As an increasing trend towards short food chains is occurring, such as dairy or meat farms hosting also processing and selling activities to (local) consumers, and as it is more challenging for small and medium sized food enterprises, mainly due to a lack of resources, competencies and economical disadvantages because of their small scale and limited power towards suppliers, in **chapter 3** an in-depth case study will be presented. In this case study the food safety culture (according to the conceptual model proposed in chapter 1) of independent micro scale farm butcheries, exemplifying a short food chain, and affiliated butcher shops, affiliates of one large scale centrally coordinated meat distribution company, representing the conventional food chain, were assessed and compared.

In **chapter 4** the goal was to investigate the impact of organizational characteristics in a more quantitative nation-wide study (no in-depth case study as presented in chapter 3). In this chapter, the food safety climate in Belgian food processing companies is assessed, still on the level of the organization. Also the impact of organizational characteristics is investigated in this chapter.

As in **chapter 4**, conclusions could only be based on results of the food safety climate self-assessment tool, which might involve an important bias, as the tool assesses 'perceptions' of employees and might not represent the actual situation, in **chapter 5** a methodological triangulation will be performed. Jespersen and Wallace (2017) stress that relying on one single method in food safety culture research, could lead to wrong conclusions. In a food service organization consisting of 9 university restaurants and 7 university cafeterias spread over different locations, two system and product related methods (internal audits and verification of registration data), assessing the performance of the food safety management system and as such belonging to the techno-managerial route, will be compared with a people related method using the food safety climate self-assessment tool, which is belonging to the human route. By triangulation of these 3 methods different aspects of 'food safety culture', as defined in chapter 1, can be investigated.

A second layer which will be investigated, is the level of the individual employee, as in the end it is the individual which will make certain decisions or adopt certain behaviors. What drives an individual employee to adopt a certain food safety behavior and which mechanisms are behind this? This third specific objective to 'study food safety climate and culture at the level of the individual employee' was worked out in **chapter 6**.

In **chapter 6** the focus is shifted from the organization as a whole, to the individual employee and the impact of individual characteristics on food safety behavior. The relation between food safety climate and employees' food safety behavior is unraveled. The conceptual model of food safety culture from chapter 1 is expanded, introducing: food safety behavior (composed of food safety compliance and food safety participation), food safety knowledge, food safety motivation, burnout and jobstress of the individual employees in the organization. Based on three research questions this expanded conceptual model will be investigated.

In **chapter 7** a general discussion of the research, reflections and future perspectives are presented.

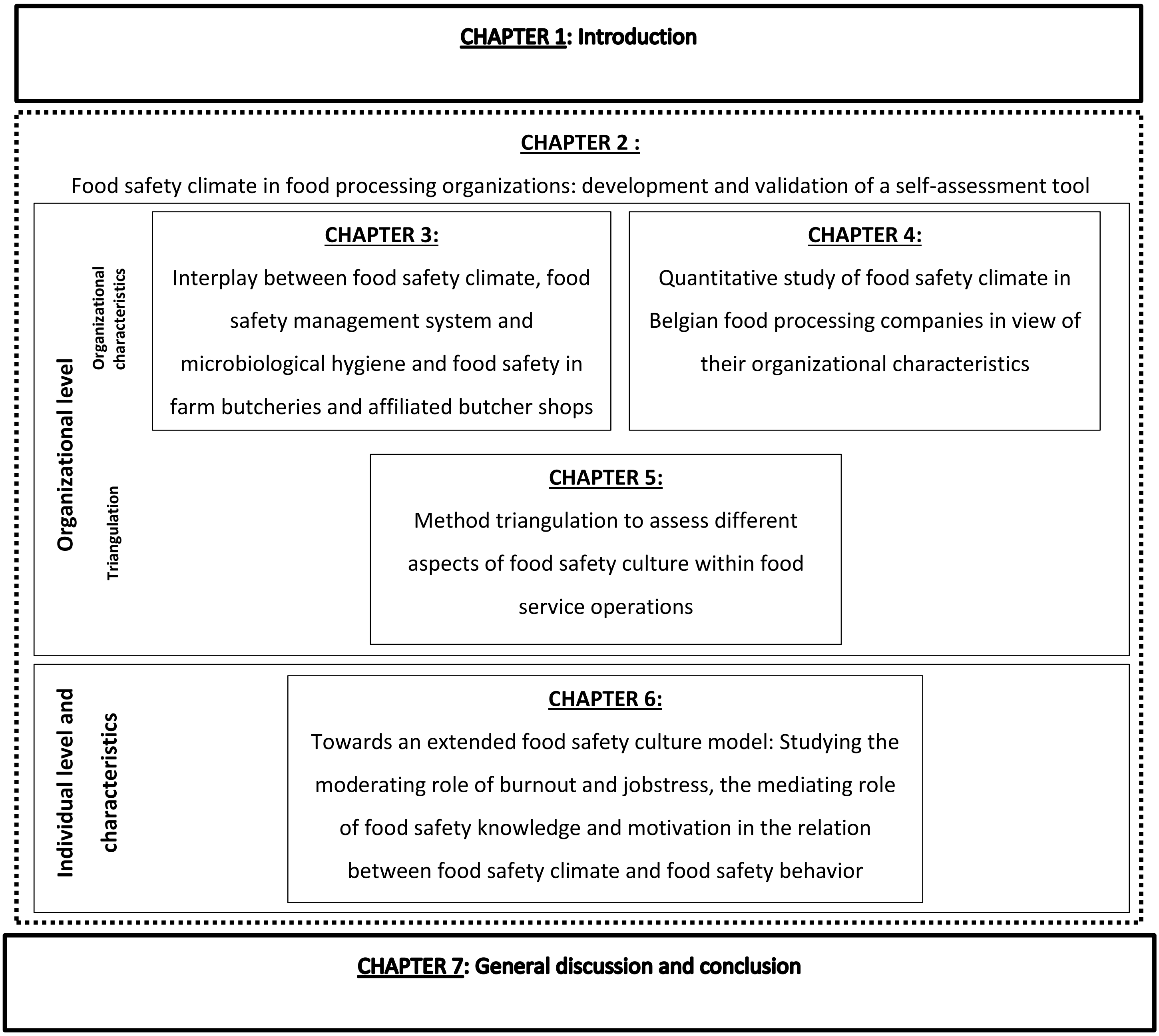

Figure 0.1. Overview of the different chapters of this doctoral dissertation

Summary

In the time period 2000 - 2015 many legal documents and guidelines on international, European and national level resulted in the development and implementation of food safety management systems, as a system consisting of Pre-requisite programs (PRPs), HACCP (Hazard Analysis and Critical Control Points) based procedures and other principles laid down in the 'General Food Law' (EC, 2002) or 'Codex Alimentarius' General Principles on Food Hygiene' (CAC, 2003), to manage food safety and hygiene in food businesses along the agro-food chain. Principles, legislative requirements and research related to food safety management systems are reviewed in **chapter 1**, illustrating that food safety management system implementation (barriers) and performance assessment of these systems are already well-investigated and described.

Still, in practice, a well-elaborated and 'fit-for-purpose' food safety management system, cannot guarantee that the level of food safety and hygiene is constantly high and stable. Foodborne outbreaks still occur and have frequently been linked to human behavior (e.g. (non)-compliance to procedures), especially in case of microbiological hazards, as illustrated in **chapter 1**. Food safety culture and food safety climate were introduced, mirroring the human dimension in food safety and food safety management. Exploring this human factor in food safety management was set as the overall objective of this doctoral dissertation. In **chapter 1** a conceptual model was presented and definitions for food safety culture and climate were developed. In this doctoral dissertation, food safety culture is defined as the interplay of the food safety climate as perceived by employees and management at all levels of a company (so called 'human route') and the implemented food safety management system, which will be influenced by the available technology, company characteristics and the context of the company (so called 'techno-managerial route'), resulting in a certain level of food safety and hygiene of the final food products (and production environment). Food safety climate, being a constituent of food safety culture, is defined as employees' (and management's) (shared) perception of leadership, communication, commitment, resources and risk awareness concerning food safety and hygiene within their current work organization.

In **chapter 2** the first specific objective of this doctoral dissertation was attained, i.e. 'the development and validation of a tool to measure food safety climate in food companies'. Based on literature study and discussion with experts, five or six indicators/statements were developed for each of the food safety climate components (leadership, communication, commitment, resources, risk awareness) resulting in a food safety climate self-assessment tool with 28 indicators and a Likert answer scale (1→5 : totally disagree → totally agree). The tool was then validated by experts, not involved in the development of the preliminary tool, with expertise in food safety/quality and food safety management systems in food companies. A pilot study in affiliated butcher shops illustrated how assessment of an organization's food safety climate can lead to interesting and challenging insights in the human dimension of their organization.

The second specific objective 'study food safety climate and culture at an organizational level' was attained in **chapters 3, 4 and 5**. In these chapters food safety climate and culture were studied in the organization as a whole, taking into account organizations' characteristics.

In **chapter 3**, the potential impact and relationship of company size and structure on food safety culture and climate was investigated in an in-depth case study. Food safety culture and climate (as proposed in our conceptual model) of independent micro scale farm butcheries, and affiliated butcher shops, affiliates of one large scale centrally coordinated meat distribution company, were assessed and compared. Both types of fresh meat selling points are operating in a risky microbiological context, which can be counteracted by a well-elaborated food safety management system in case of the affiliated butcher shops. In case of the farm butcheries, the food safety management system is only basic and not tailored to the company-own situation. Also, the food safety climate was at a higher level in the centrally managed butcher shops, which was especially reflected in differences in perceptions related to communication and leadership concerning food safety and hygiene. The high (perceived) level of food safety climate by the affiliated butcher shop employees, was confirmed by the high level of microbiological hygiene and safety of the products and production environment in the affiliated butcher shops. The lower level of food safety and hygiene of the farm butcheries might be linked to the lower level of the food safety management system and the need to invest further in proper implementation of good practices. The fact that farm butchery employees still perceived the food safety climate to be on a high level (83.26% of responses were 4 'Agree' or 5 'Totally agree'), although this was at a lower level than in the affiliated butcher shops, could indicate that optimistic bias or complacency exists, as they are not fully aware of the food safety and hygiene issues in their organization.

In **chapter 4,** the impact of organizational characteristics on an organization's food safety climate was investigated in a more quantitative nation-wide study in Belgian food processing industry. Based on the perceptions of 136 quality managers/plant managers/production managers, food safety climate can be considered good in the responding Belgian food processing companies, as, overall, 50.5% of all responding companies agreed and 24.7% totally agreed with the statements/indicators of the food safety climate assessment tool. Based on our data, it can be stated that quality/plant/production managers employed in companies with multiple sites in Belgium appeared to perceive the food safety climate at a higher level than managers employed in one-site companies. Also providing more than one training session per year appeared to result in a significantly better perception of the food safety climate by the companies' quality/plant/production managers. For the other organizational characteristics investigated (such as company size, sector, presence of quality department, time spent on quality control, certification, available budget for maintaining the food safety management system) no significant correlations with the food safety climate could be proven. Exploratory factor analysis revealed the existence of four underlying factors: factor 1 mainly dealing with 'leadership related' indicators, factor 2 with 'resources related' indicators, factor 3 with 'communication related' indicators and factor 4 is a mix of mainly 'risk awareness related' indicators and some 'commitment related' indicators. This factor solution is only partly in line with the five dimensions (leadership, communication, commitment, resources and risk awareness) of food safety climate, as proposed in this doctoral dissertation. Still, as results provide evidence that these factors are correlated, it might be that defining completely distinct components/factors is rather difficult.

In **chapter 5**, a methodological triangulation was performed illustrating how a more comprehensive evaluation of food safety culture (as proposed in our conceptual model) can be obtained by combining both techno-managerial route oriented (by verification of Critical Control Points monitoring data and internal audits) and human route oriented (by food safety climate self-assessment tool) assessment methods. As a case-study, these three methods were applied assessing the food safety culture in food service operations of a Belgian university, consisting of 9 university restaurants and 7 university cafeterias spread over different locations in the city of Ghent but centrally managed. Different aspects of food safety culture could be investigated and weaknesses of one method can be mitigated by strengths of other methods. For example, information about issues related to employee compliance with procedures, infrastructure, equipment and work methodology can be provided through verification of Critical Control Points monitoring data and internal audits, whilst insights in employee and location responsible perceptions concerning leadership, communication, commitment, resources and risk awareness could be gained through the use of the food safety climate self-assessment tool. Moreover, locations where food safety climate was perceived to be at a high level, whilst internal audit and verification results indicated that the level of food safety and hygiene was rather low, can be identified. As such specific strategies can be developed and applied at these locations for example, to mitigate this potential hazard of optimistic bias and complacency.

In the end, it is the individual which will make certain decisions or adopt certain behaviors. This individual level was investigated in **chapter 6**, in line with the third specific objective of this doctoral dissertation: 'study food safety climate and culture at the level of the individual employee'. The conceptual food safety culture model as described chapter 1 was expanded by introducing 'food safety behavior' (composed of food safety compliance and participation, which represent obligated food safety related activities and additional voluntary food safety related activities), ‘food safety knowledge’, ‘food safety motivation’, ‘burnout’ and ‘jobstress’ of the individual employees in the organization. This conceptual model was tested through statistical analysis with data (n=85) collected from two Belgian vegetable processing companies through self-assessment surveys. A significant and positive relationship between food safety climate and employees’ behavior was found. Mediation analysis showed that food safety knowledge cannot fully explain the relationship between food safety climate and food safety behavior (partial mediation). Also, food safety motivation appeared to be a partial mediator between food safety climate and compliance and behavior (not for food safety participation). The proposed moderation effect of jobstress and burnout was not confirmed. Still, both variables appeared to be strongly correlated with food safety behavior, suggesting that the management should consider and try to reduce these psychosocial risk factors in the workplace.

Based on the knowledge gained in the above-mentioned chapters, a general discussion and final conclusion were formulated in **chapter 7**. Four important findings and practical implications for food companies could be deduced over all chapters of this doctoral dissertation. Firstly, food companies, willing to improve their food safety culture, need to investigate how effective the leadership and communication concerning food safety and hygiene is within the company. Secondly, by triangulation of both techno-managerial route and human route oriented methods, a more comprehensive evaluation of an organization’s food safety culture and potential hazards of optimistic bias and complacency among employees can be identified. Thirdly, a food company can increase food safety motivation and knowledge by providing regular and effective education and training. Fourthly, food companies need to consider the importance of psychosocial well-being, as evidence was provided that burnout and jobstress are correlated with food safety behavior.

Samenvatting

De hele reeks wettelijke documenten en richtlijnen die op internationaal, Europees en nationaal niveau in voege traden in de periode 2000-2015, resulteerden in de ontwikkeling en implementatie van voedselveiligheidssystemen, ingevoerd als een systeem, bestaande uit basisvoorwaardeprogramma's, procedures gebaseerd op Hazard Analysis and Critical Control Points (HACCP) en andere principes zoals vastgelegd in de 'General Food Law' (EC, 2002) en de 'Codex Alimentarius General Principles on Food Hygiene' (CAC, 2003), om de voedselveiligheid en hygiëne te beheersen van riek tot vork. Principes, wettelijke vereisten en onderzoek omtrent voedselveiligheidssystemen werden bestudeerd in **hoofdstuk 1**. Hieruit blijkt dat onderwerpen gelinkt aan implementatie van voedselveiligheidssystemen, moeilijkheden hierbij en de prestatiebeoordeling van deze systemen al talrijk onderzocht en beschreven zijn.

Toch wordt in de praktijk vastgesteld dat zelfs een goed uitgewerkt en 'fit-for-purpose' voedselveiligheidssysteem, geen constant hoog en stabiel niveau van voedselveiligheid en hygiëne kan garanderen. Voedselgebonden uitbraken worden nog steeds gerapporteerd en werden reeds vaak geassocieerd met menselijke gedrag (bijvoorbeeld het (niet) nakomen van procedures), zeker in geval van microbiologische gevaren, zoals geïllustreerd in **hoofdstuk 1.** Voedselveiligheidscultuur en voedselveiligheidsklimaat, begrippen die de menselijke factor in voedselveiligheid en het beheersen van voedselveiligheid weerspiegelen, werden in dit hoofdstuk geïntroduceerd. Het onderzoeken van deze menselijke factor bij het beheersen van de voedselveiligheid is dan ook het centrale thema van dit proefschrift. In **hoofdstuk 1** werd een conceptueel model voorgesteld en definities voor voedselveiligheidscultuur en -klimaat werden ontwikkeld. Voedselveiligheidscultuur werd in dit proefschrift gedefinieerd als: de wisselwerking tussen het voedselveiligheidsklimaat, zoals gepercipieerd door de werknemers en het management op alle hiërarchische niveaus (de 'humane route' genoemd) en het geïmplementeerde voedselveiligheidssysteem, dat wordt beïnvloed door de beschikbare technologie, karakteristieken en de context van de organisatie (de 'technologie-management route' genoemd), resulterend in een bepaald niveau van voedselveiligheid en hygiëne van de geproduceerde eindproducten (en productieomgeving). Voedselveiligheidsklimaat maakt deel uit van de voedselveiligheidscultuur en kan gedefinieerd worden als de (gedeelde) perceptie van werknemers (en management) over het leiderschap, de communicatie, het engagement, de beschikbare middelen en het risico-bewustzijn inzake voedselveiligheid en hygiëne in hun huidige werkorganisatie.

In **hoofdstuk 2** werd een eerste specifiek doel van dit proefschrift bereikt, i.e. 'het ontwikkelen en valideren van een tool om voedselveiligheidsklimaat in voedingsbedrijven te meten'. Op basis van literatuurstudie en discussies met experten, werden vijf of zes indicatoren/uitspraken ontwikkeld voor elk van de voedselveiligheidsklimaatcomponenten (leiderschap, communicatie, engagement, beschikbare middelen en risico-bewustzijn), resulterend in een voedselveiligheidsklimaat zelfbeoordelingstool met 28 indicatoren en een Likert-gebaseerde antwoordschaal (1 → 5: helemaal oneens → helemaal eens). Vervolgens werd de tool gevalideerd door experten die niet betrokken waren in de ontwikkelingsfase van de tool, met expertise in voedselveiligheid en voedselveiligheidssystemen in voedingsbedrijven. Een pilootstudie in geaffilieerde slagerijen illustreerde hoe het meten van het voedselveiligheidsklimaat van een organisatie kan leiden tot interessante en uitdagende inzichten in de menselijke factor van de organisatie.

Het tweede specifieke doel van dit proefschrift, namelijk 'het onderzoeken van voedselveiligheidscultuur en -klimaat op niveau van de organisatie' werd bestudeerd in **hoofdstukken 3, 4 en 5.** In deze hoofdstukken werden de voedselveiligheidscultuur en het klimaat van de organisatie als geheel onderzocht, waarbij ook de link met organisatiekenmerken in rekening werd gebracht.

In **hoofdstuk 3**, werd de potentiële impact en relatie van organisatiegrootte en structuur op/met voedselveiligheidscultuur en klimaat (volgens het voorgestelde conceptueel model) onderzocht in een diepgaande casestudy**.** De voedselveiligheidscultuur en het voedselveiligheidsklimaat van zelfstandige microschaal hoeveslagerijen werden bestudeerd en vergeleken met de cultuur en het klimaat in geaffilieerde slagerijen die deel uitmaken van een groot centraal-gecoördineerd vleesdistributiebedrijf. Beide types vleesverkooppunten opereerden in een risicovolle microbiologische context, wat kon gecounterd worden door een goed uitgewerkt en 'fit-for-purpose' voedselveiligheidssysteem in het geval van de geaffilieerde slagerijen. In de hoeveslagerijen, was er een eerder elementair/generisch voedselveiligheidssysteem voorhanden, dat niet was aangepast aan de specifieke situatie van de slagerijen. Ook het voedselveiligheidsklimaat bevond zich op een hoger niveau in de centraal-gecoördineerde geaffilieerde slagerijen, wat zich vooral uitte in verschillen in percepties omtrent communicatie en leiderschap. Het hoog gepercipieerde niveau van het voedselveiligheidsklimaat door de werknemers in de geaffilieerde slagerijen, werd bevestigd door het hoge niveau van microbiologische voedselveiligheid en hygiëne van de voedingsproducten en de productieomgeving in deze slagerijen. Het lager niveau van voedselveiligheid en hygiëne in de hoeveslagerijen kan mogelijks gelinkt worden aan het lagere niveau van het voedselveiligheidssysteem en de noodzaak om verder te investeren in adequate implementatie van goede praktijken. Het feit dat de werknemers in de hoeveslagerijen toch percipieerden dat het voedselveiligheidsklimaat in hun organisatie zich op een hoog niveau bevond (83.26 % van de antwoorden waren 4 'Eens' of 5 'Helemaal eens'), hoewel dit toch lager werd gepercipieerd dan in de geaffilieerde slagerijen, zou kunnen aantonen dat er een optimistische vertekening ('bias') of zelfgenoegzaamheid heerst onder de werknemers, gezien deze zich niet helemaal bewust waren van problemen omtrent voedselveiligheid en hygiëne in hun organisatie.

In **hoofdstuk 4** werd de impact van organisatiekenmerken op voedselveiligheidsklimaat onderzocht in een meer kwantitatieve studie in de Belgische voedselverwerkende industrie. Op basis van percepties van leidinggevenden uit 136 verschillende bedrijven, kan gesteld worden dat het voedselveiligheidsklimaat in de betrokken Belgische voedselverwerkende bedrijven op een vrij hoog niveau wordt ingeschat, gezien over het algemeen 50.5 % van de betrokken bedrijven het eens waren (4 'Eens') en 24.7 % het helemaal eens waren (5 'Helemaal eens') met de uitspraken/indicatoren van de voedselveiligheidsklimaat meettool. Uit de verkregen data bleek dat de respondenten werkzaam in bedrijven met meerdere sites in België, het voedselveiligheidsklimaat in hun organisatie op een significant hoger niveau inschatten dan respondenten werkzaam in bedrijven met slechts één site. Wat betreft de overige organisatiekenmerken die werden onderzocht (zoals organisatiegrootte, sector, aanwezigheid van een kwaliteitsdepartement, tijd gespendeerd aan kwaliteitscontrole, certificatie status, beschikbaar budget voor het onderhouden van het voedselveiligheidssysteem), werd er geen statistisch significante correlatie met het voedselveiligheidsklimaat aangetoond.

Uit een exploratieve factoranalyse bleek dat er op basis van de antwoorden op de voedselveiligheidsklimaat zelfbeoordelingstool, vier onderliggende factoren konden geëxtraheerd worden: factor 1 die vooral 'leiderschap gerelateerde' indicatoren bevat, factor 2 met vooral 'middelen gerelateerde' indicatoren, factor 3 met 'communicatie gerelateerde' indicatoren en factor 4 bevat vooral 'risicobewustzijn-gerelateerde' en enkele 'engagement-gerelateerde' indicatoren. Deze factoroplossing is slechts gedeeltelijk in lijn met de vijf dimensies, zoals voorgesteld in dit proefschrift. Toch, gezien de resultaten aantoonden dat de geëxtraheerde factoren gecorreleerd zijn, is het mogelijks moeilijk om volledig gescheiden componenten/factoren te definiëren.

In **hoofdstuk 5** werd een methodentriangulatie uitgevoerd, waarbij werd aangetoond hoe een meer diepgaande evaluatie van de voedselveiligheidscultuur (volgens het voorgestelde conceptueel model) kan bekomen worden door zowel 'technologie-management route' (via verificatie van monitoring data van kritische controlepunten en interne audits) en 'humane route' (via voedselveiligheidsklimaat zelfbeoordelingstool) gebaseerde evaluatiemethoden toe te passen. Als casestudy werden drie methoden gecombineerd om de voedselveiligheidscultuur te evalueren van een cateringorganisatie van een Belgische universiteit, bestaande uit 9 universiteitsrestaurants en 7 universiteitscafetaria's, verspreid over verschillende locaties in Gent, maar wel centraal gecoördineerd. Verschillende aspecten van de voedselveiligheidscultuur konden onderzocht worden en de zwakheden van de éne methode konden worden opgevangen door sterktes van andere methoden. Zo kon er bijvoorbeeld informatie met betrekking tot problemen omtrent het (niet) navolgen van procedures, infrastructuur, uitrusting en werkmethodologie verkregen worden via verificatie van monitoring gegevens van kritische controlepunten en interne audits. Terwijl via de voedselveiligheidsklimaat zelfbeoordelingstool inzichten in percepties over leiderschap, communicatie, engagement, beschikbaarheid van middelen en risicobewustzijn in de organisatie, van werknemers en locatie verantwoordelijken konden bekomen worden. Meer nog, locaties waar werknemers ervaarden dat de voedselveiligheidscultuur zich op een hoog niveau bevond, terwijl de resultaten van interne audits en verificatie van monitoring data suggereerden dat het niveau van voedselveiligheid en hygiëne eerder laag was, konden worden geïdentificeerd. Zo kunnen specifieke strategieën worden ontwikkeld en toegepast op deze locaties om bijvoorbeeld dit potentiële gevaar van optimistische bias en zelfgenoegzaamheid aan te pakken.

Uiteindelijk is het individu verantwoordelijk voor het maken van bepaalde beslissingen of het aannemen van een bepaald gedrag. Dit individueel niveau werd onderzocht in **hoofdstuk 6**, in lijn met het derde specifieke doel van dit proefschrift: 'het onderzoeken van voedselveiligheidsklimaat en cultuur op het niveau van de individuele werknemer'. Het conceptueel voedselveiligheidscultuur-model, zoals besproken in **hoofdstuk 1**, werd uitgebreid door het introduceren van 'voedselveiligheidsgedrag' (bestaande uit zowel verplichte als additionele vrijwillige voedselveiligheidsactiviteiten), 'kennis', 'motivatie', 'burn-out' en 'job stress' van de individuele werknemer in de organisatie. Dit conceptueel model werd getest via statistische analyse op basis van data (n=85) verzameld in twee Belgische groenten verwerkende bedrijven via zelfbeoordelingsvragenlijsten. Een significante en positieve relatie tussen voedselveiligheidsklimaat en het gedrag van werknemers werd vastgesteld. Verder toonde mediatie-analyse aan dat voedselveiligheidskennis de relatie tussen voedselveiligheidsklimaat en voedselveiligheidsgedrag niet volledig kan verklaren (partiële mediatie). Ook voedselveiligheidsmotivatie bleek te fungeren als een partiële mediator tussen voedselveiligheidsklimaat en voedselveiligheidsgedrag (enkel voor verplichte voedselveiligheidsactiviteiten, niet voor vrijwillige activiteiten). Hoewel het vooropgestelde moderatie effect van job stress en burn-out niet kon worden aangetoond, bleken beide variabelen sterk gecorreleerd te zijn met het voedselveiligheidsgedrag, wat suggereert dat het management van een organisatie aandacht moet hebben voor deze psychosociale risicofactoren in de werkomgeving en moet trachten om deze te minimaliseren.

Op basis van de kennis verworven in de bovengenoemde hoofdstukken, werd een algemene discussie en finale conclusie geformuleerd in **hoofdstuk 7**. Over alle hoofdstukken van dit proefschrift heen, konden vier belangrijke bevindingen en praktische implicaties voor voedingsbedrijven worden afgeleid. Vooreerst, werd uitgelegd dat voedingsbedrijven die hun voedselveiligheidscultuur willen verbeteren, kunnen onderzoeken hoe effectief het leiderschap en de communicatie met betrekking tot voedselveiligheid en hygiëne verloopt binnen het bedrijf. Ten tweede, via triangulatie van zowel ‘technologie-management route’ gebaseerde en ‘humane route’ gebaseerde methoden, kan een meer diepgaande evaluatie van de voedselveiligheidscultuur in een bedrijf bekomen worden. Bovendien, kunnen potentiële gevaren gelinkt aan optimistische bias en zelfgenoegzaamheid aan het licht worden gebracht. Ten derde, een voedingsbedrijf moet trachten om de voedselveiligheidsmotivatie en –kennis van werknemers te verbeteren door regelmatige en effectieve training en opleiding. Ten vierde, voedingsbedrijven moeten aandacht hebben voor psychosociaal welzijn van werknemers, gezien burn-out en job stress sterk gerelateerd zijn aan voedselveiligheidsgedrag.

Chapter 1

Introduction

1.1 Food safety management systems (FSMS): where from and where to?

1.1.1 Food safety management systems

'Food safety' is a broad concept, for which no unanimously recognized definition exists. For a common understanding of this concept, as 'food safety' will have a central position in this manuscript, the definition proposed by the Scientific Committee of the Belgian FASFC (Federal Agency for Safety in the Food Chain) will be adopted, i.e.: "the condition of the foodstuffs in all stages of production, processing and distribution, required to guarantee protection of consumer's health, also taking into account normal circumstances of use and information available for the foodstuffs concerned. Food safety thus means the absence of biological, chemical or physical agents (hazards) in concentrations/quantities that can cause adverse health effects" (Baert et al., 2011).

With respect to food safety, both chronic and acute health effects can be considered. Acute health effects, refer to adverse health effects caused by a single (or very short-term) exposure to a hazard (often linked to microbiological hazards), whereas chronic health effects are caused by long-term exposure (often linked to chemical hazards) (EFSA, 2018). Furthermore, both intentional and unintentional food safety issues can be investigated. In this doctoral dissertation, only 'unintentional food safety issues' will be considered, although 'intentional food safety issues' may also pose a major risk (vide infra).

Closely related and an essential requirement to achieve 'food safety', is 'food hygiene', defined as "all conditions and measures necessary to ensure the safety and suitability of food at all stages of the food chain" (Codex_Alimentarius, 2017). The concept 'food quality' is broader than food safety and hygiene, and also comprises, for example, sensorial and convenience properties of food products (Grunert, 2005). In the current doctoral dissertation focus will be on food safety and hygiene.

On an international level food safety and hygiene are discussed by the Codex Alimentarius Commission (CAC), which is established by the Food and Agriculture Association of the United Nations (FAO) and the World Health Organization (WHO) with as main goal to protect consumer health and promote food trade. CAC offers standards and guidelines which are used worldwide as a basis for national legislation related to food safety and hygiene (Codex_Alimentarius, 2017). A well-known and used basic document published by CAC is the 'Codex Alimentarius General principles on food hygiene' (CAC/RCP1-1969 (CAC, 2003)), identifying essential principles of food hygiene throughout the food chain and recommending a Hazard Analysis and Critical Control Point principles (HACCP) based approach to identify hazards and evaluate risks.

On a European level, three regulations are of key importance in this matter. Firstly, the introduction of the General Food Law (EC., 2002) forced food industry to change, laying down important principles such as the precautionary principle, risk analysis approach, traceability and the fact that the primary responsibility for food safety of food products placed on the market lies with the food business operator (FBO). Secondly, the EU Regulation 852/2004 (EC., 2004b) imposed general hygiene requirements to be applied by all food business operators along the food chain (from farm to fork). Thirdly, also some specific hygiene requirements (EU Regulation 853/2004) for food of animal origin were introduced at that time (EC., 2004c). The translation of these hygiene requirements, including GHPs, GMPs, GAPs etc. into practically manageable, effective and company specific programs according to the plan-do-check-act principle are called Pre-requisite programs (PRPs) (e.g. cleaning and disinfection, waste control, temperature control) (EU_Commission, 2016; Lahou, 2016). A second important requirement imposed by EU Regulation 852/2004 (EC., 2004b) is the development, implementation and maintenance of procedures based on HACCP (except for primary production). Of course, hygiene requirements existed already before these regulations, although these were more vertical (product category specific) and particularly oriented towards animal based products (Dwinger & De Smet, 2016).

The three abovementioned European Regulations form the legal basis for the current European Food Safety Management System (FSMS), which is further explained in the Commission Notice on the implementation of food safety management systems (EU_Commission, 2016) and defined as “a holistic system of prevention, preparedness and own-check activities to manage food safety and hygiene in a food business consisting of PRPs, HACCP based procedures and other management policies securing the other principles laid down in the general food law”.

The fact that the FSMS needs to be planned, implemented and checked by the food business operator, led to the term ‘self-checking system’, which is used in some countries to refer to the FSMS e.g. Belgium (Jacxsens et al., 2009; Luning et al., 2009). The EU Commission notice (EU_Commission, 2016) was developed in order to facilitate and harmonize implementation of EU requirements related to the FSMS, but also to clarify flexibilities which are foreseen in legislation to ensure the requirements can be applied in all situations, taking into account nature and size of the company. For example, the direct supply of small quantities of primary products to the final consumer is excluded from the scope of EU Regulation 852/2004 (EC., 2004b). EU Regulation 852/2004 (EC., 2004b) also encourages the development and use of guides to good practice to help FBOs to control hazards and demonstrate compliance. Many of such guides have already been developed and assessed by competent authorities for several food sectors. These are mostly dealing with PRPs but can also cover some or all HACCP-based principles (EC., 2017b; FASFC, 2017). In fact, since its publication in

Codex Alimentarius in the 1990's, HACCP is considered an inseparable part of the FSMS to be implemented in all food processing companies (except primary production). Still, although these principles exist for many years, it is not that evident for food companies 'to make it work' in practice (Wallace, 2014). Wallace, Holyoak, Powell, and Dykes (2014) state that poor knowledge and lack of training and experience can weaken both design, implementation and maintenance of the HACCP system and point out that problems are often not originating from failures of the HACCP system itself, but rather the way it is being applied and supported (Wallace, 2014). Also Mortimore (2001) addresses the importance of competency of people who both develop and operate the HACCP system, and stresses the significance of the PRPs, which support it.

Some authors (e.g. Fotopoulos, Kafetzopoulos, and Psomas (2009)) consider the 'FSMS' equal to the 'HACCP system', although a FSMS is more than HACCP alone (EU_Commission, 2016). Wallace, Sperber, and Mortimore (2011) are speaking of a 'world-class food safety programme', which includes safe product/process design (e.g. performing challenge tests at development stage), PRPs and HACCP supported by essential management practices which are dealing with, for example, management commitment and responsibilities. This is in line with the definition proposed in the Commission Notice (vide supra) in which three building blocks are described: PRPs, HACCP based procedures and other management policies and interactive communication to ensure effective traceability and recall (EU_Commission, 2016).

According to the research of Luning, Bango, Kussaga, Rovira, and Marcelis (2008) the self-checking system or FSMS, as defined above, should contain both quality control and assurance activities. To clarify the used terminology related to food safety and quality, it should be mentioned that in some European countries, including Belgium, the terms quality control, quality department, quality team… are more commonly used in food industry than food safety control, food safety department, food safety team. Although the concept 'food quality' is broader than food safety and hygiene, and also comprises, for example, sensorial properties of food products (Grunert, 2005), main focus is still on the food safety aspect, and this terminology is used in Belgium within the scope of the FSMS. In line with the common terminology used in Belgium the term 'quality control' is used throughout this doctoral dissertation. Quality control activities are typically related to product and process controls aiming at prevention of food safety hazards, whilst assurance activities are providing objective evidence (e.g. by sampling, internal audits) that products and processes are complying with the requirements (Jacxsens et al., 2009; Luning et al., 2008). Both types of activities can be technological (e.g. cleaning and disinfection program as control activity; sampling plan as an assurance activity) or managerial (e.g. availability of procedures as control activities; executing internal audits as assurance activities) in nature (Jacxsens et al., 2011; Kirezieva, Nanyunja, et al., 2013). Luning and Marcelis

(2007) state that applying control systems and procedures is not sufficient, as both food products/production and behavior of people (employees and consumers as well) are dynamic and complex. The authors propose a techno-managerial approach to support a broader analysis of quality and food safety issues involving both technological (“technology dependent activities necessary to achieve a product with certain physical properties”) and managerial (“necessary decision-making activities to activate the food production system as well as the management system, to give it the right direction, and to ensure that it meets consumer and customer requirements”) functions necessary to manage food safety and quality in an integrative way (Luning & Marcelis, 2007). Furthermore, Luning, Marcelis, et al. (2011b) and Kirezieva, Nanyunja, et al. (2013) stressed the importance of the specific company context, depending on product characteristics, process characteristics, organizational characteristics and chain environment characteristics, to which the activities of the company specific FSMS should be adapted. Figure 1.1 gives a schematic overview of a FSMS and its positioning within a food company and its context (vide supra, e.g. Luning, Marcelis, et al. (2011b)) and output, i.e. the level of hygiene and food safety of the produced products. The FSMS is represented as being composed of PRPs, HACCP based procedures and other management policies securing principles laid down in the general food law (as defined in the EU Commission Notice (EU_Commission, 2016), vide supra), but can also be considered, according to the approach of Luning et al. (2008), as the whole of quality control and quality assurance activities, which can be both technological and managerial in nature (Jacxsens et al., 2011).

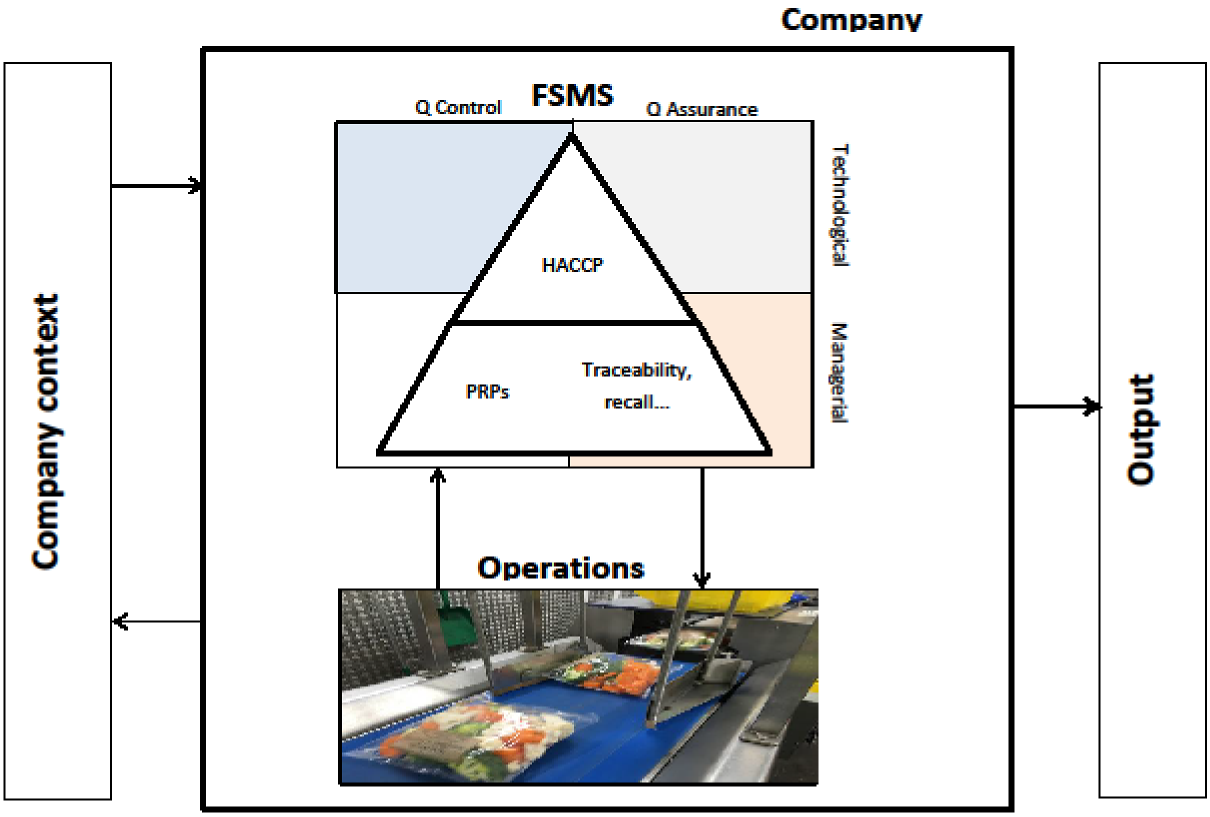

Figure 1.1: Schematic overview of a FSMS and its positioning within a food company and its context and output (level of hygiene and food safety of the produced food products). Q: Quality

1.1.2 Impact of organizational characteristics of food businesses on food safety management systems

The impact of organizational characteristics on the FSMS is already widely studied (e.g. Kirezieva, Nanyunja, et al. (2013)). 'Organizational characteristics' is a rather broad concept, of which several definitions exist. For example in the research of Luning, Marcelis, et al. (2011a) organizational characteristics, within this research considered as part of the context of a company (Figure 1.1), refer to "administrative conditions, such as people characteristics (e.g. competence), organizational structures (e.g. division of tasks, responsibilities, rules, procedures), and information systems, which affect peoples' decision-making behavior" (p.74). In the current doctoral dissertation the definition of Simon (1976) (cited by Magnier-Watanabe and Senoo (2008)) was adopted: "Organizational characteristics are features originating both from the management model adopted by the organization, through its structure or strategy and, from the company culture embodied in the nature of its membership and relationships" (Simon, 1976).

The Belgian food and drink industry housed in 2015 4425 companies (Food_BE, 2017). This high number can be explained by a large number of small and medium-sized companies. In 2015, 53.4% of all food companies employed less than 5 employees and 83.4 % fewer than 20 employees. No more than 168 companies employed more than 100 employees (Food_BE, 2017). Several authors provided evidence that the implementation of a FSMS is much more challenging for small and medium size food companies (e.g. Antony, Kumar, and Labib (2008); Walker, Pritchard, and Forsythe (2003)).

However, as already mentioned in section 1.1.1, some flexibilities are foreseen in legislation taking into account nature and size of the company, such as exclusion of the direct supply of small quantities of primary products to the final consumer from the scope of EU Regulation 852/2004 (EC., 2004b). Another example, specifically for certain types of small retail establishments, namely butcheries, groceries, bakeries and fish and ice cream shops, is the recent publication of a scientific opinion by the EFSA (European Food Safety Authority) Panel on Biological Hazards (BIOHAZ) on request of the EU Commission (EFSA_BIOHAZ, 2017). A simplified approach for hazard analysis was proposed for the above mentioned types of independent small retail establishments, which are serving to local customers, employing a limited number of employees and having a limited share of the available market, by use of flow diagrams, without the need for detailed description of activities and hazards. Control is achieved using PRPs (no Critical Control Points (CCPs)) and only where required, critical limits, monitoring and record keeping should be applied. Furthermore, this scientific opinion was translated by the EU Commission in a 'Guidance document for certain small food retailers' (EU_Commission, 2017), available in official EU languages in order to be used by small retailers in all member states.

Still, only considering the size of a company, Jacxsens et al. (2015) could not find a significant difference in FSMS performance in their study in the Belgian food processing industry (including distribution and retail). The authors assessed FSMS performance based on the robustness of control and assurance activities and the level to which these are fit-for-purpose, by means of a validated diagnostic tool composed of a set of indicators (Luning, Jacxsens, et al., 2011). Faour-Klingbeil, Kuri, and Todd (2015) saw that corporate managed food service establishments had a significantly higher interest, knowledge and awareness on food safety practices than independent food service establishments. The authors state that corporate managed food service operations are more structured in their food safety procedures and operations/support and management priorities related to food safety are more clear for the employees.

With regard to sector, some differences in FSMS performance could be noticed. In a study in Belgian food processing companies (Jacxsens et al., 2015), animal food products processing companies such as fish, meat or dairy appeared to have a more robust FSMS, with more elaborated control and assurance activities than non-animal product processing companies (e.g. fruit/vegetables and potato processing). This could be partly due to the historical course of EU legislation, as almost since its creation, veterinary health rules to ensure safe movement of animals and animal products within the EU market were laid down in the EU (Dwinger & De Smet, 2016). In the study of Jacxsens et al. (2015), product (e.g. contamination of raw materials) and process (e.g. susceptibility of the process to contamination, environmental conditions) characteristics of non-animal product processing seemed to be less risky, based on a set of indicators as part of a diagnostic tool used in this study (Luning, Marcelis, et al., 2011a). Animal food products intrinsically have higher prevalences of pathogens and remain the most often implicated food vehicles in foodborne outbreaks (EFSA_and_ECDC, 2016). As riskiness of product characteristics comprises, among others, the probability of contamination, growth, and survival of pathogens, and other undesired micro-organisms such as spoilage micro-organisms, animal based food products can be considered on a higher risk level (Jacxsens et al., 2015). However, although lower prevalences are reported on fresh produce (EFSA_and_ECDC, 2016), contamination of fresh produce should not be overlooked, as there is often no intervention step (e.g. cooking) before consumption (Wadamori, Gooneratne, & Hussain, 2017). Furthermore, due to the increasing fresh produce consumption, foodborne outbreaks related to fresh fruits and vegetables are emerging (Lynch, Tauxe, & Hedberg, 2009).

The FSMSs of the non-animal product processing companies participating in the study of Jacxsens et al. (2015) were less elaborated and not fit-for-purpose. However, these companies still managed to achieve a good food safety output, assessed through a set of indicators as part of the diagnostic tool (e.g. number of complaints) (Jacxsens et al., 2010), which confirms the findings of Luning et al. (2009) stating that the level of the FSMS should be adapted to the riskiness of the context. This means that food companies with a lower risk context (e.g. non-animal products processing companies), may not have an FSMS to the most advanced level. This is also confirmed in the study of Dora, Kumar, Van Goubergen, Molnar, and Gellynck (2013) performed in three EU countries, where it is stated that implementation of quality management tools is more advanced in the meat sector (and the chocolate, confectionary industry), than in bakery, packaged fruits and vegetables sectors.

In Belgium it is encouraged to validate the company's FSMS or 'self-checking system' by means of audits, which can be conducted by the Federal Agency for Safety in the Food Chain (FASFC) or by a acknowledged commercial certification body. As defined in ISO 9000:2015 (ISO, 2015a) an audit is "a systematic, independent and documented process for obtaining objective evidence and evaluating it objectively to determine the extent to which the audit criteria are fulfilled". Sector associations or industry association play a mediating role in this certification system, as auditing reference standards are national agreed guides per sector on HACCP and best practices, approved by the Belgian FASFC (Jacxsens et al., 2015; RD., 2003). Having a certified self-checking system has some advantages for food companies such as a lower inspection frequency by the FASFC and a lower annual financial contribution to the FASFC. In the study of Jacxsens et al. (2015) in Belgium certification of the self-checking system did not show a significant difference in FSMS performance. However, assurance activities (e.g. validation and verification activities, set-up of sampling plan) were more elaborated in companies with a certified self-checking system. Through these third party audits companies can also choose to be certified against commercial standards (e.g. BRC, IFS, ISO) which consider, besides the food safety aspect, also food quality requirements (Jacxsens et al., 2015). In the study of Jacxsens et al. (2015) in Belgium, 90% of the participating food processing companies were already certified for such voluntary commercial standards, next to the Belgian certification of the self-checking system (50% of the participating companies). Trafialek and Kolanowski (2017) saw that implementation and functioning of HACCP principles was higher in certified food companies than in non-certified companies. Also, in the study of Nanyunja et al. (2016) in Kenyan green bean production the demand for compliance with strict voluntary food safety standards in order to export to EU, resulted in a shift to a more advanced FSMS and a good output.

Unsatisfactory performance of quality or food safety management systems can be both due to problems related to control activities and problems related to assurance activities (Luning et al., 2009). Typical problems mentioned in literature are: e.g. inappropriate assessment of CCPs and monitoring systems, lack of validation and verification, poor food handler behavior,…(Panisello & Quantick, 2001; Taylor & Kane, 2005; Walker et al., 2003). Also training appears to be an important factor to improve hygienic conditions and practices in food businesses (Garayoa, Diez-Leturia, Bes-Rastrollo, Garcia-Jalon, & Vitas, 2014; Soares, Garcia-Diez, Esteves, Oliveira, & Saraiva, 2013).

1.1.3 Assessing food safety management system performance (and food safety /food hygiene performance) in food companies

The performance, being defined by ISO as ‘a measurable result’ (ISO, 2015a), of the FSMS can be evaluated in several ways and this evaluation can be initiated or driven at different levels. Nanyunja (2015) distinguishes three levels in the supply chain: the micro-, meso- and macro- level. The micro-level is dealing with the ‘chain operators’ where the product is produced, i.e. the level of the company. At the meso-level Nanyunja (2015) uses the term ‘chain supporters’, as this level consists of supporting organizations, representing common interests of the supply chain operators (e.g. sector/industry associations). The macro level of the supply chain is the level of the ‘chain enablers’ like governments, legislative and regulatory institutions and other public organizations, which can for example, set legislative requirements related to evaluation of performance of FSMSs.

For example, at the level of the ‘chain enablers’, EU Regulation 882/2004 (EC., 2004a) prescribes that the competent authority has to establish and implement a risk based Multi-Annual National Control Plan (MANCP). As such, the Belgian Federal Agency for the Safety of the food Chain (FASFC), the official authority responsible for official controls in all stages of the food chain developed this control program consisting of product analyses and inspections (FASFC, 2012). The product analyses control program deals with all (bio)chemical, physical and microbiological analyses of products to check their food safety. These sampling plans can be imposed by legislation decided on EU level (e.g. zoonoses program, or pesticide monitoring program) or based on risk through a risk ranking approach to set priorities in products (e.g. SciCom (2006)). The inspection control program is aiming at controlling FSMSs or self-checking systems of food businesses at all stages of the food chain (FASFC, 2012). In case of Belgium, a company can also choose for an external audit or third party audit by an independent certification body to validate the company’s self-checking system (vide supra), which can be considered a micro-level performance assessment.

Powell et al. (2013) utter several critiques on (third party) audits and inspections and state that audits, inspections and testing is not enough to guarantee food safety. For example, the author raises the fact that audits and inspections are only a snapshot in time and cannot guarantee future performance. Effectiveness also depends on the effectiveness of the audit tool and the auditor competence. The most important remark is the fact that audit or inspection reports are only useful if audit results are taken seriously and considered as an opportunity and guidance for improvement of food safety practices in the organization. This links to the underlying motivation for obtaining the audit; just because of customer demand or does the organization really value the improvement of food safety and quality in the organization? Certification is no guarantee that food safety/food hygiene issues are a thing of the past, as many foodborne illness outbreaks have been linked to organizations which obtained already some form of certification (Powell et al., 2013). Therefore, several authors (Moss & Martin, 2009; Powell et al., 2013) but also European legislation (EC., 2002), stress that the primary responsibility to ensure food safety of the products lies with the food business operator. As audits and inspections are only a snapshot in time, obtaining certification should not be a reason to resign in the obtained success. A potential approach could be to consider the third party (certification) audit as an aid for strengthening self-audit methods and operational controls (Costa, 2010). At the level of the FBO the self-audit or internal audit can be considered as a powerful tool for practical evaluation of the FSMS which can contribute to the revelation of major food safety/food hygiene problems in the company (Osimani, Aquilanti, Tavoletti, & Clementi, 2013a; Powell et al., 2013). Internal audits are most often led by the quality assurance team of the organization. Second party audits are audits performed by a company on the supplier of ingredients.

All raw material suppliers should be included in the audit scope for an effective audit system (Powell et al., 2013). Powell et al. (2013) describe some cases in which second party audits were able to identify problems third party audits missed. Moreover the importance of open communication between suppliers and buyers is stressed, as close cooperation with suppliers to help achieve the organization's objectives may enhance results and reinforce a culture of food safety throughout the chain. Besides audits, several academics propose a more scientific approach for evaluation of the FSMS through the development of diagnostic tools using performance indicators (Luning et al., 2008; Luning, Marcelis, et al., 2011b).

In Table 1.1 the results of a literature review of scientific publications between 2009 and June 2017 are shown, with the objective to investigate how performance of the FSMS is measured in food industry. The complete list of all obtained papers can be found in Appendix 1.A. Search terms were entered in Web of Science (Web_of_Science, 2017) and based on title and abstract, relevant publications were withheld. Appendix 1.B gives an overview of all search terms which were used and the number of relevant publications for each search term. Included were papers or books, dealing with performance assessment of the FSMS, applied in companies in the agro-food chain (including primary production, processing, distribution, retail, food service…). Papers related to food safety performance of consumers were excluded. Also press releases and thesis dissertations were excluded. Important to note is that the objective was not to perform a complete systematic review of all existing literature, but rather to get an idea of the main FSMS performance assessment methods which are currently in use. In Table 1.1 two types of performance measurements are distinguished. 'System and product related performance measurements' are composed of microbiological analyses, inspections by the competent authority, external audits by an official organization, internal audits by the researchers, the use of diagnostic instruments developed by scientists and others. 'People related performance measurements' look more at individual employees and go beyond assessing the performance of only the FSMS. So actually this can be considered broader as a 'food safety/food hygiene performance' assessment. For example, knowledge, behavior or perception of the employees can be evaluated through checklists, surveys, observations or interviews. Some studies look at performance before and after an intervention (e.g. food safety training).

Table 1.1: Number of publications in the period 2009-June 2017 dealing with FSMS performance measurement. Number of publications is also given per type of performance measurement.

		Type of performance measurement									
		System and product related						People related			
Year	**Number of publications**	**Microbiologi-cal analyses**	**Inspections**	**Internal audits**	**External audits**	**Diagnostic instrument**	**Other**	**Knowledge**	**Behavior/ pracitces**	**Perception**	**Culture/Climate**
2009	2	1/2				1/2					
2010	5	1/5				3/5		1/5	1/5		1/5
2011	5	4/5			1/5	2/5		1/5	2/5		
2012	6	3/6				2/6		1/6	2/6		
2013	14	6/14		2/14	1/14	4/14	1/14	3/14	4/14		1/14
2014	8	4/8		1/8		3/8	1/8	1/8	1/8	1/8	
2015	17	3/17	3/17			8/17		6/17	6/17	2/17	
2016	11	1/11	1/11		1/11	5/11	1/12		1/11		1/11
2017	5	1/5	1/5	1/5		2/5		1/5		1/5	
Total	**73**	**24/73**	**5/73**	**4/73**	**3/73**	**30/73**	**3/73**	**14/73**	**17/73**	**4/73**	**3/73**
		Only System and product related: 52/73						Only People related: 14/73			
		Both types of performance measurements: 5/73									

The literature review resulted in 73 studies in total, with 52 studies only dealing with system and product related performance measurements, 14 only people related performance measurements and 5 studies applied both types of measurements. Most studies were performed in Europe (46 of 73), especially in Belgium and the Netherlands (18 of 73) and Spain (12/73). Seven studies were performed in US and another 7 papers in African countries (e.g. South Africa and Kenya) (see Appendix 1.A). Table 1.1 also shows that the number of publications dealing with FSMS performance increased over the period 2009-2017 and also more people related methods came in use (especially in 2015). Microbiological analyses and diagnostic instruments seemed to be the most popular system and product related measurements (24 and 30 studies respectively), followed by inspections by competent authorities described in only five papers, and four and three studies dealing with internal and external audits respectively. Based on the current review, no chemical analyses were performed as part of assessing FSMS performance. Concerning the people related performance measurements, behavior/practices (17 papers) and knowledge (14 papers) are most often assessed, generally by means of self-assessment questionnaires; perception (e.g. about food safety risks) was only assessed in four papers. Table 1.1 provides evidence that food safety performance in the food industry is generally assessed by system and product related performance measurements without considering the people aspect.

The fact that in recent years more and more scientists are developing diagnostic tools to assess FSMS and, broader, food safety/food hygiene performance in food companies (Djekic et al., 2014; Luning, Marcelis, et al., 2011a), suggests that there is an increased interest in measurements systems or tools, able to assess the food safety/hygiene (and FSMS) performance in food companies. However, these tools are mainly system and product based and might miss the importance of the people aspect in food safety management. Although main focus is still on system performance, Kafetzopoulos and Gotzamani (2014) already acknowledged that also employee attributes are important factors for food safety system effectiveness. The authors mention employee know-how, commitment and involvement and human resources availability as indicators. Psomas, Fotopoulos, and Kafetzopoulos (2010) also studied critical factors for effective implementation of the ISO 9001 standard in SMEs. They mention attributes of the company, requirements of the quality system, attributes of the external environment, internal motivation of the company and employee attributes. This suggests that performance of the FSMS is more than only system related performance. The papers dealing with people related measurements are often looking at the effectiveness of training on food safety practices (Rowell, Binkley, Alvarado, Thompson, & Burris, 2013; Soon & Baines, 2012). In 3 of the 73 papers the culture or climate prevailing in the organization was studied (see Table 1.2 for excerpt from Appendix 1.A). One paper looked at organizational climate and the impact on food

Table 1.2: List of publications in which climate/culture is proposed to assess food safety/hygiene performance in food companies (based on review of literature in period 2009-June 2017). NA: Not applicable. (Excerpt from Appendix 1.A)

		Type of performance measurement											
		System and product related						People related					
Reference	**Title**	**Microbiological analyses**	**Inspections**	**Internal audits**	**External audits**	**Diagnostic instrument**	**Other**	**Knowledge**	**Behavior/ practitces**	**Perception**	**Culture/ Climate**	**Country**	**Company type**
Griffith, Livesey, and Clayton (2010a)	The assessment of food safety culture										Food safety culture	NA	Food industry
Lee, Almanza, Jang, Nelson, and Ghiselli (2013)	Does transformational leadership style influence employees' attitudes toward food safety practices?								X		Organizational climate	US	Food service operations
Nyarugwe, Linnemann, Hofstede, Fogliano, and Luning (2016)	Determinants for conducting food safety culture research										Food safety culture	The Netherlands	Food industry

safety practices. Two papers are really using the term' food safety culture' in relation to food safety performance of food companies.

In summary, it can be stated that FSMS and broader food safety/hygiene performance assessment is often based on system and product related performance measurements. Luning and Marcelis (2007) already acknowledged the unpredictability of food systems and behavior of people, introducing an up to now widely described approach going beyond only looking at technological quality/food safety aspects: the techno-managerial approach (Luning, Jacxsens, et al., 2011; Milios, Zoiopoulos, Pantouvakis, Mataragas, & Drosinos, 2013) (vide supra). Although the authors acknowledge the importance of human behavior and decision making, they mainly focus on decision making in a managerial context (e.g. design of a quality policy), rather than really considering the level of the individual food handler/operator. Still, several authors (e.g. Powell, Jacob, and Chapman (2011) and Yiannas (2009)) provide evidence that many foodborne outbreaks could be traced back to mistakes (e.g. inadequate handwashing practices) of individual food handlers.

1.2 Human behavior in the food industry

The European Center for Disease Control (ECDC) and EFSA reported in their EU summary report on trends and sources of zoonoses, zoonotic agents and foodborne outbreaks in 2015 (EFSA_and_ECDC, 2016), a total of 4362 foodborne outbreaks, representing 45874 cases of illness, 3892 hospitalizations and 17 deaths. For 409 strong evidence outbreaks, households were the most frequent place of exposure (45.7%). However at the second place, with 23.7% of outbreaks, canteens and other catering settings where food is prepared and/or served, were reported, closely followed by the category 'Restaurant, pub, street vendor and take away' with 19.5%. In outbreaks related to households *Salmonella* spp. was most often identified as causative agent. Viruses (and bacterial toxins) were more frequently related to catering services and restaurants.

In 2014 viruses (adenovirus, calicivirus, hepatitis A virus, flavivirus, rotavirus and other unspecified viruses) were the most frequently reported causative agent (20.4%) (followed by *Salmonella* spp.) of foodborne outbreaks. Main place of exposure was also households (37.3%), followed by restaurants, pubs, cafés, hotels, bars (26%) (EFSA_and_ECDC, 2015). In Belgium, 351 foodborne outbreaks were reported in 2015, with 1673 illnesses and 40 hospitalizations. Main causative agent were *Bacillus cereus* toxins and main places of exposure (76.6%) were restaurants and take away-fast food services (WIV-ISP, 2016).

Besides outbreaks or illnesses caused by microbiological agents, also chemical hazards can be present in food products. Examples of chemical hazards are excessive presence of process contaminants such as the (probable) human carcinogens acrylamide, furan and monochloropropanediol (MCPD). Thermal processes are inducing formation of these toxic components and, although these processes are inherent to food industry, concentrations can vary depending on process settings/parameters (Mogol & Gokmen, 2016). Another group of chemical hazards are residues exceeding their MRL such as pesticides, veterinary drugs. Also presence of not indicated allergens is gaining importance and can cause severe reactions in sensitive people.

In order to investigate whether there is a link between food safety problems and practices/behavior of food handlers, a review of available scientific literature between 2009 and 2017 was carried out. Search terms were entered in Web Of Science (Web_of_Science, 2017) and based on title and abstract relevant publications were withheld. Appendix 1.C gives an overview of all search terms which were used and the number of relevant publications for each search term. Included were papers or books, in which evidence is provided for the link between food handler/operator behavior or practices and food safety problems. As food handlers/operators we consider, all people working in the agro-food chain (including e.g. primary production and food services). Food safety problems are considered as: "the absence of biological, chemical or physical agents (hazards) in concentrations/quantities that can cause adverse health effects (Baert et al., 2011)". Publications dealing with consumer behavior were excluded and also press releases and thesis dissertations were not included.

It was not the objective to perform a complete systematic review of all existing literature, but rather to get a general overview of publications studying the link between microbiological/chemical hazards and human behavior. Results for microbiological hazards in European and non-European countries are given in, respectively, Table 1.3a and 1.3b. Results for chemical hazards and allergens are given in Table 1.3c (both European and non-European). In total 41 scientific publications (Table 1.3a-c) were found in which a direct link between food safety problems and food handler behavior/practices was mentioned. Although many studies are published concerning chemical hazards (e.g. process contaminants, allergens), studies looking at the link with human behavior of employees were still scarce (only 6 of 41 publications, see Table 1.3c). Besides the 6 publications which were withheld (Table 1.3c), hits through Web Of Science were mainly dealing with formation reactions, detection methods and exposure studies (Garballo-Rubio, Soto-Chinchilla, Moreno, & Zafra-Gomez, 2017; Leigh & MacMahon, 2017). Only two papers were dealing with the role of food handlers/employees in the presence of process contaminants. The other four papers were dealing with knowledge and need for training of employees and managers concerning food allergens, suggesting the important role of human behavior in allergen management (Table 1.3c). In contrast, the role of food handler practices and behavior on transmission of pathogens and consequent outbreaks is already widely investigated

(35 of 42 studies) (Table 1.3a and 1.3b). Many of these studies were executed in the restaurant or catering sector.

In summary, it can be stated that in many cases, human behavior and more specifically behavior and practices of food handlers/employees, can be directly linked to food safety problems in food industry. Furthermore, besides the cases described above, which are considered to be 'unintentional' in nature, human behavior/practices can also be linked to 'intentional food safety issues', also called 'food fraud'. A frequently used definition for 'food fraud' is the following: "Food fraud is a collective term used to encompass the deliberate and intentional substitution, addition, tampering, or misrepresentation of food, food ingredients, or food packaging; or false or misleading statements made about a product, for economic gain" (Spink & Moyer, 2011). Spink and Moyer (2011) distinguish seven food fraud incident types: Adulteration (e.g. melamine added to milk), tampering (e.g. changing expiry information), over-run (e.g. underreporting of production), theft (stolen products mixed with legitimate products), diversion (sale of products out of intended markets), simulation (e.g. "knock-offs' of popular foods without the same food safety assurances) and counterfeit (e.g. copies of popular foods without the same food safety assurances).

Some authors (e.g. Oliveri and Downey (2012)) study a specific type of food fraud, 'food authenticity'. 'Authentic' can be defined as "a word to describe an object that is not false or copied, it is genuine and real. Authentic food is food (or drink) that exactly meets its description and also meets a person's reasonable assumption of its character" (Foodfraudadvisors, 2018). A typical example is olive oil blended with cheaper vegetable oil or unrighteous claims regarding the geographical origin of the oil (e.g. cheaper Greek oil instead of claimed 'Italian olive oil'). Within the food fraud incident types, as defined by Spink and Moyer (2011), food authenticity can be considered to belong to different incident types. Looking at the example of the olive oil (vide supra), counterfeit and adulteration can be considered. Not all food fraud incidents have direct food safety consequences, e.g. selling of cheaper Greek or Turkish olive oil which is labeled as 'Italian' olive oil. The olive oil can then be sold at a higher prices, but this does not have direct consequences for food safety of the product (Johnson, 2014). However, in the example of adulteration of milk by adding melamine, food safety is clearly jeopardized, as melamine can cause damage to the excretory organs, kidney, and bladder (Gossner et al., 2009). Important to note is that in case of food safety problems as a consequence of food fraud, hazards are most often chemical in nature, whilst Tables 1.3a-c demonstrate clearly that microbiological food safety issues dominate in an unintentional setting. Though, not denying the importance of food fraud in food industry, the current doctoral dissertation will focus more on the unintentional practices resulting in food safety issues.

Table 1.3a: Results of literature review (scientific publications between 2009 and 2017) concerning food safety problems originating from food handler practices/behavior for microbiological hazards in Europe. (Total number of publications: 15)

Reference	Title	Hazard	Cause of food safety problem	Country	Company type
Barrabeig et al. (2010)	Foodborne norovirus outbreak: the role of an asymptomatic food handler	Norovirus GII.2	Transmission through asymptomatic food handler was cause of the outbreak.	Spain	Lunch on summer camp
Diercke et al. (2014)	Transmission of shiga toxin-producing *Escherichia coli* O104:H4 at a family party possibly due to contamination by a food handler, Germany 2011	*E. coli* O104:H4	The food handler was not symptomatic during preparation of the food, but recently visited her daughter in the hospital who was suffering from bloody diarrhea caused by STEC O104:H4.	Germany	Catering
Ercoli et al. (2017)	Investigation of a Staphylococcal Food Poisoning Outbreak from a Chantilly Cream Dessert, in Umbria (Italy)	*Coagulase positive staphylococci*	The outbreak was caused by a food handler. Moreover, the chantilly cream dessert was improperly stored at room temperature for about 5 h, permitting microbial growth and toxin production.	Italy	Restaurant
Franck et al. (2015)	Sources of Calicivirus Contamination in Foodborne Outbreaks in Denmark, 2005-2011-The Role of the Asymptomatic Food Handler	Calicivirus	In all reported calicivirus outbreaks in Denmark during the period (2005-2011), upto one quarter of the outbreaks were caused by asymptomatic food handlers.	Denmark	Not specified
Gallina et al. (2013)	Staphylococcal poisoning foodborne outbreak: epidemiological investigation and strain genotyping	*Staphylococcus aureus*	Nasal mucosa of 3 employees was swabbed, samples were taken from vomit and feces of 4 hospitalized customers. All swabs and samples were positive for *S. aureus*, but genotyping revealed that only 1 employee was responsible for transmission to the food vehicle: a seafood salad.	Italy	Catering

Reference	Title	Hazard	Cause of food safety problem	Country	Company type
Iturriza-Gomara and O'Brien (2016)	Foodborne viral infections	Enteric viruses, hepatitis viruses and emerging and zoonotic viruses	The study points out that up to 25% of Norovirus outbreaks is attributable to asymptomatic food handlers.	Not specified	Not specified
Kuo et al. (2009)	A foodborne outbreak due to norovirus in Austria, 2007	Norovirus GII	A ham roll was responsible for the outbreak. An asymptomatic food handler, whose child was suffering from gastroenteritis, prepared this food product. RT PCR analysis confirmed that gastroenteritis was caused by norovirus.	Austria	Restaurant
Lunestad et al. (2016)	An Outbreak of Norovirus Infection from Shellfish Soup Due to Unforeseen Insufficient Heating During Preparation	Norovirus	The outbreak during a company Christmas celebration in Norway, December 2013 was attributed to insufficient heat treatment during preparation of a shellfish soup in serving portions.	Norway	Company catering
Maritschnik et al. (2013)	A food-handler associated, foodborne norovirus GII.4 Sydney 2012-outbreak following a wedding dinner, Austria, October 2012	Norovirus GII.4 Sydney	One member of the kitchen personnel was working during a marriage dinner, although he was suffering from diarrhea. Employees did not receive training concerning food safety and hygiene and in the toilet for the kitchen personnel necessary facilities for hand hygiene were not available.	Austria	Catering
Robesyn et al. (2009)	An outbreak of hepatitis A associated with the consumption of raw beef	Hepatitis A virus GIA	Molecular sequencing showed that sequences from serum and feces samples of the patients corresponded to these of the employee of the butchery.	Belgium	Butchery
Rumble et al. (2017)	Role of Food Handlers in Norovirus Outbreaks in London and South East England, 2013 to 2015	Norovirus	17 outbreaks in the period between 2013 and 2015 were further investigated. Symptomatic food handlers were tested positive for norovirus in five outbreaks. Symptomatic food handlers were not tested in four outbreaks. Asymptomatic food handlers were tested positive for norovirus in one of the three outbreaks tested.	UK	Food outlets and catering

Reference	Title	Hazard	Cause of food safety problem	Country	Company type
Sanchez et al. (2017)	Norovirus GII.17 Outbreak Linked to an Infected Post-Symptomatic Food Worker in a French Military Unit Located in France	Norovirus GII.17	An association was found between illness and cake consumption. The Norovirus strain was spread through food worker hand contact.	France	Military Unit
Soon, Seaman, and Baines (2013)	*Escherichia coli* O104:H4 outbreak from sprouted seeds	*E. coli* O104:H4	Human fecal contamination of sprouted seeds appeared to be the cause of the EHEC crisis.	Germany and France	Primary production
Vo et al. (2016)	An Outbreak of Norovirus Infections Among Lunch Customers at a Restaurant, Tampere, Finland, 2015	Norovirus	Inadequate hygiene practices of the kitchen staff was considered as the cause of norovirus transmission. Also the Level of hygiene in the kitchen was inadequate.	Finland	Restaurant
Zomer et al. (2010)	A foodborne norovirus outbreak at a manufacturing company	Norovirus GI.3	More than 400 employees of a Swedish company got sick because of norovirus GI.3 contamination after taking lunch in the company. Further investigation identified the tomatoes of the salad buffet and the hamburgers as the most probable source of transmission. The employee responsible for the preparation of these food products tested positive for norovirus GI.3 and admitted to have vomited 11h before the start of the lunch.	Sweden	Company canteen

Table1.3b: Results of literature review (scientific publications between 2009 and 2017) concerning food safety problems originating from food handler practices/behavior for microbiological hazards outside Europe. (Total number of publications: 20)

Reference	Title	Hazard	Cause of food safety problem	Country	Company type
Adam, Yoder, Gould, Hlavsa, and Gargano (2016)	Giardiasis outbreaks in the United States, 1971-2011	*Giardia intestinalis*	Foodborne outbreaks of *Giardia intestinalis* were most commonly related to fresh produce prepared in a restaurant by a food handler. Poor food handler hygiene is an important prevention measure.	US	Restaurants
Angelo, Nisler, Hall, Brown, and Gould (2017)	Epidemiology of restaurant-associated foodborne disease outbreaks, United States, 1998-2013	Not specified, norovirus caused the largest number of outbreaks (46%).	Investigation of restaurant-associated foodborne disease outbreaks from 1998 to 2013 in the USA revealed that the most commonly reported contributing factors were those related to food handling and preparation practices in the restaurant (2955 outbreaks, 61%).	US	Restaurants
Bradley et al. (2012)	Epidemiology of a large restaurant-associated outbreak of Shiga-toxin producing *Escherichia coli* O111:NM	*E. coli* O111:NM	Epidemiological data suggests that transmission of *E. coli* O111 was caused through hands of an infected employee or through cross contamination of utensils or surfaces to the food. In both possible cases, the outbreak is caused by one or more employees.	US	Restaurant / catering
Chai, Cole, Nisler, and Mahon (2017)	Poultry: the most common food in outbreaks with known pathogens, United States, 1998-2012	*Salmonella enterica ,Clostridium perfringens*	Poultry-associated foodborne outbreaks in the US between 1998 and 2012 were most often linked to restaurants (37% of poultry-associated outbreaks), followed by private homes (25%), and catering facilities (13%). Food handling errors (64%) and inadequate cooking (53%) appeared to be the most commonly reported contributing factors.	US	Restaurants, private homes and catering facilities

Reference	Title	Hazard	Cause of food safety problem	Country	Company type
Chen, Chen, Chen, Hsu, and Lo (2016)	An outbreak of norovirus gastroenteritis associated with asymptomatic food handlers in Kinmen, Taiwan	Norovirus gastroenteritis	An outbreak of gastroenteritis in 2015 in Taiwan was attributed to norovirus through consumption of pork liver and lamb chops, which may have been contaminated by asymptomatic infected food handlers. Further investigation showed that hand washing facilities were not properly accessible to food handlers, as such, inappropriate hygiene practices of food handlers may have contributed to the outbreak.	Taiwan	Canteen
Figgatt et al. (2017)	Giardiasis Outbreak Associated with Asymptomatic Food Handlers in New York State, 2015	*G. duodenalis*	An outbreak of 20 giardiasis cases was linked to a local grocery store chain on Long Island, New York. Three asymptomatic food handlers appeared to be infected with *G. duodenalis*, and one food handler and one case were coinfected with *Cryptosporidium* spp.	US	Grocery store
Hall et al. (2012)	Epidemiology of Foodborne Norovirus Outbreaks, United States, 2001-2008	Norovirus	Investigation of foodborne norovirus outbreaks in the US between 2001 and 2008 showed that infected food handlers were the source of 53% of outbreaks and may have contributed to 82% of outbreaks.	US	Not specified
Hall, Wikswo, Pringle, Gould, and Parashar (2014)	Vital Signs: Foodborne Norovirus Outbreaks - United States, 2009-2012	Norovirus	Investigation of foodborne norovirus outbreaks in the US between 2001 and 2008 showed that disease outbreaks are most often associated with contamination of food in restaurants during preparation by infected food workers.	US	Not specified
Harada et al. (2013)	A foodborne outbreak of gastrointestinal illness caused by enterotoxigenic *Escherichia coli* serotype O169:H41 in Osaka, Japan	*E. coli* O169:H41	One of the employees' feces tested positive for *E. coli* O169:H41. He was suffering from diarrhea some days before the festival. But he did come to work. During the festival the normal capacity of the restaurant was exceeded, because of which hygiene and food safety could have been jeopardized.	Japan	Restaurant (festival)
Hedican et al. (2009)	Restaurant *Salmonella* Enteritidis outbreak associated with an asymptomatic infected food worker	*Salmonella* Enteritidis	*Salmonella* Enteritidis which was detected in 5 customers, was also found in 2 asymptomatic employees. One of the employees was responsible for the preparation of the food product (sandwiches) responsible for the outbreak.	US	Restaurant

Reference	Title	Hazard	Cause of food safety problem	Country	Company type
Hedican et al. (2010)	Salmonellosis outbreak due to chicken contact leading to a foodborne outbreak associated with infected delicatessen workers	*Salmonella* Montevideo	Two employees of the grocery store tested positive for the subtype of *Salmonella* (Montevideo), which caused disease in several persons eating ready-to-eat foods, purchased in the grocery store.	US	Ready-to-eat foods in grocery store
Herman, Hall, and Gould (2015)	Outbreaks attributed to fresh leafy vegetables, United States, 1973-2012	norovirus (55% of outbreaks with confirmed aetiology), Shiga toxin-producing *Escherichia coli* (STEC) (18%), and *Salmonella* spp. (11%).	85% of the outbreaks attributed to fresh leafy vegetables were caused by food prepared in a restaurant or catering facility (85%). In 31% of the outbreaks, an ill food worker was implicated as the source of contamination .	US	Restaurant and catering
Holman, Allen, Holguin, Torno, and Lachica (2014)	A community outbreak of *Salmonella enterica* serotype typhimurium associated with an asymptomatic food handler in two local restaurants	*Salmonella enterica* serotype Typhimurium	From January to April 2012, 22 cases of *Salmonella enterica* serotype Typhimurium were reported. PFGE-patterns were similar and all patients were living in Long Beach, California and most of the patients ate in 1 of 2 restaurants in Long Beach. These 2 restaurants were owned by the same person and 2 employees were employed in both restaurants. One of the employees' feces was positive for *Salmonella* with a PFGE-pattern similar to the sick customers.	US	Restaurants
Juliao et al. (2013)	National outbreak of type A foodborne botulism associated with a widely distributed commercially canned hot dog chili sauce	*Clostridium botulinum*	Because of lack of monitoring of the system, the cause of the insufficient heat treatment could not be found. FDA stated that several violations could have led to survival of *C. botulinum* spores after canning. Sterilization equipment was not well maintained and not correctly operated. Also indicator lights of the alarm system were not working and equipment for temperature monitoring was not calibrated.	US	Canning factory

Reference	Title	Hazard	Cause of food safety problem	Country	Company type
Kobayashi et al. (2012)	A foodborne outbreak of sapovirus linked to catered box lunches in Japan	Sapovirus GI.2	In 7 of the 52 employees of the catering company, sapovirus was detected. Two of the employees had symptoms of gastroenteritis; the other 5 employees were asymptomatic. The nucleotide profile of the strain found in the employees was the same as in the sick customers.	Japan	Catering
Liu, Tam, et al. (2015)	A Foodborne Outbreak of Gastroenteritis Caused by *Vibrio parahaemolyticus* and Norovirus through Non-Seafood Vehicle	*Vibrio parahaemolyticus* and Norovirus	Both pathogens were originating from roasted duck, an uncommon non-seafood vehicle for this mixed infection and further research revealed that a single asymptomatic food handler was responsible for both pathogens. The suboptimal hygiene practices were the cause of the high rate of infection .	China	Catering
Thornley et al. (2013)	Multiple outbreaks of a novel norovirus GII.4 linked to an infected post-symptomatic food handler	Recombinant norovirus GII.e/GII.4	Three of the employees tested positive for the norovirus variant which was found in the feces of sick customers. One of the employees got sick 4 days before the outbreak. As such, this employee was still infectious (even when symptoms already disappeared), at the moment he was preparing the food, causing the outbreak.	New Zealand	Catering
Venuto, Garcia, and Halbrook (2015)	Analyses of the Contributing Factors Associated With Foodborne Outbreaks in School Settings (2000-2010)	Microbiological (mainly Norovirus)	Investigation of foodborne outbreaks in school settings in USA between 2000 and 2010 showed that 56% of all illnesses were associated with norovirus and food service worker practices.	US	School canteens
Wu, Wen, Ma, Ma, and Chen (2014)	Epidemiology of foodborne disease outbreaks caused by *Vibrio parahaemolyticus*, China, 2003-2008	*Vibrio parahaemolyticus*	Outbreaks of foodborne disease caused by *Vibrio parahaemolyticus*, in China, during 2003-2008 most frequently occurred in restaurants (39%), cafeterias (30%), and private residences (15%) and were in 50% of the cases caused by cross contamination (50%). Food workers and consumers should receive training in order to avoid cross contamination of ready-to-eat foods with uncooked seafoods.	China	Restaurants cafeterias and private residences
Yu, Kim, Koh, and Lee (2010)	Epidemiology of foodborne norovirus outbreak in Incheon, Korea	Norovirus GII.4	None of the employees had symptoms of gastroenteritis before the incident. The feces samples of 2 of 11 employees tested positive for norovirus. Asymptomatic employee A was involved in preparing some dishes with high risk and could be responsible for the outbreak.	Korea	School canteen

Table 1.3c: Results of literature review (scientific publications between 2009 and 2017) concerning food safety problems originating from food handler practices/behavior for allergens and chemical hazards. (Total number of publications: 6)

Reference	Title	Hazard	Cause of food safety problem	Country	Company type
Ajala et al. (2010)	Food allergens: Knowledge and practices of food handlers in restaurants	Food allergens	Many restaurants have no real allergen policy and no training was given to food handlers.	Brazil	Restaurants
Gowland and Walker (2015)	Food allergy, a summary of eight cases in the UK criminal and civil courts: effective last resort for vulnerable consumers?	Food allergens	Cases are described in which human behavior of food suppliers (e.g. wrong information/labeling, cross contamination…) were responsible for severe allergic reactions in consumers.	UK	Not specified
Radke et al. (2016)	Food Allergy Knowledge and Attitudes of Restaurant Managers and Staff: An EHS-Net Study	Food allergens	The need for proactive training of staff about food allergies is discussed.	US	Restaurants
Sanny, Jinap, Bakker, van Boekel, and Luning (2012)	Possible causes of variation in acrylamide concentration in French fries prepared in food service establishments: an observational study	Acrylamide	Lack of standardized control of frying temperature and time, and variable practices of the employees, contributed to the variable and high concentrations of acrylamide in French fries.	The Netherlands and Malaysia	Fast-food chain and catering in university and restaurant
Sanny, Luning, Jinap, Bakker, and van Boekel (2013)	Effect of frying instructions for food handlers on acrylamide concentration in French fries: an explorative study	Acrylamide	Frying instructions were given to the employees of restaurants. The average acrylamide concentration after instruction was significantly lower than those before the instructions.	The Netherlands and Malaysia	Restaurants
Xu et al. (2014)	Anaphylaxis-related deaths in Ontario: a retrospective review of cases from 1986 to 2011	Food allergens	Fatal anaphylaxis was often related to food ingestion outside the home, which demonstrates the need for education and training on food allergen avoidance in restaurants and food service industry.	US	Restaurants

1.3 Culture and organizations

Aside of the role of human behavior, authors also suggest the potential role of organizational culture and food safety culture in food safety/food hygiene performance (see Table 1.2.). In the following paragraphs the importance of culture within organizations will be discussed.

1.3.1 Culture

Before zooming in to organizational culture and food safety culture, the concept 'culture' as such, should be considered. Many authors studied this concept, all of them using their own definitions. For example, Hofstede (1980) defines culture as "the collective programming of the mind that distinguishes the members of one group or category of people from others". Another interesting definition is the one of Coreil, Bryant, and Henderson (2001): "culture is the patterned ways of thought and behavior that characterize a social group, which can be learned through socialization processes and persist through time''. So, culture is actually what differentiates one group of people from another (Nyarugwe et al., 2016) and is 'a shared product of shared learning' (Edmondson, 2012), which can be learned by becoming part of the 'group' and is sustained over time (Yiannas, 2009). This 'group' can be considered in different ways and at different levels. For example, Hofstede, Hofstede, and Minkov (2010) distinguishes following levels: a national level, a regional and/or ethnic and/or religious and/or linguistic affiliation level, a gender level, a generation level, a social class level and organizational, departmental and corporate levels. Furthermore, culture is studied in different academic disciplines. For example, in cultural anthropology, social behavior, economical structure and religion of populations are studied (Cultural_magazine, 2017). Cultural geography is the study of cultural products and norms, their variation across spaces and places, as well as their relations (Gregory, Johnston, Pratt, Watts, & Whatmore, 2000). Culture is also used as a term for "everything that is produced by society"; within 'the arts', this relates to artistic expressions and other manifestations of human intellectual achievement, such as literature, architecture etc. (Encyclo, 2017). Askegaard and Madsen (1998) speak of 'food culture' and define this as "a culinary order whose traits are prevalent among a certain group of people, which may be distinguished from the micro-level (family) to the macro level (countries, regions, social classes, etc.)."

Of course, within the scope of this doctoral dissertation, focus is on organizations and more specifically food companies, active in processing and distribution, not primary production. As such, following paragraphs will focus on organizational culture and (food) safety culture, which can be considered, based on the research of Nyarugwe et al. (2016), as a part of the organizational culture (Figure 1.2). This organizational culture is again part of an overarching national culture. Several authors acknowledge the importance of national culture as a part of the organization's context influencing how organizations operate and shape the organization's culture (Havold, 2007; Nyarugwe et al., 2016). However, details on national culture and how this influences an organization are out of scope of this doctoral dissertation.

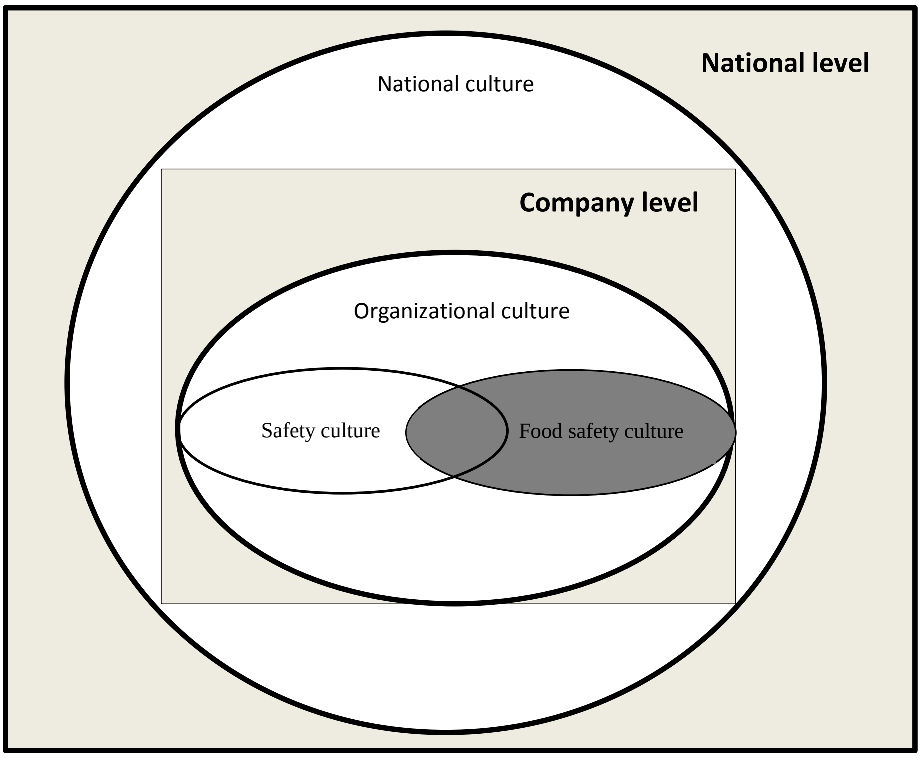

Figure 1.2: Positioning of food safety culture, and safety culture within organizational culture and national culture (adapted from Nyarugwe et al., 2016)

1.3.2 Organizational culture

In organizations, culture is "that which distinguishes organizations and shapes them into what they are" (Ashkanasy, Wilderom, & Peterson, 2000; Nyarugwe et al., 2016). Schein (2017), considered one of the principal experts in organizational culture, talks about the structure of culture and defines three 'levels' of culture, meaning the degree of visibility of the cultural phenomenon to a participant or observer. The first level is the 'artifacts', which are clearly visible and feelable structures and processes of the group, such as its language, its technology, its manner to dress, etc. Also observed behavior routines and rituals can be considered artifacts. The second level of culture, Schein (2017) defines as 'espoused beliefs and values', which are ideals, goals, values, aspirations, etc. which were initially proposed by a leader and accepted by the group because e.g. the manager convinces the group to act on this belief. If implementing these espoused beliefs and values result in repeated success, these beliefs and values transform into shared assumptions. These 'taken-for-granted underlying basic assumptions' are defined by Schein as the third level of culture. After a culture has integrated a set of such assumptions, behavior will be determined on these assumptions or shared 'thought world', and any other conflicting behavior will be found inconceivable. According to Schein (2017), these beliefs, values and desired behaviors compose the cultural DNA, which cannot be changed easily, as these will eventually drop out of awareness. However, one might wonder, if these assumptions are indeed never questioned, how can a 'bad culture' be changed. Here, Schein stresses the importance of leaders, who need to initiate change through the creation of a motivation to change, which he calls 'disconfirmation'. By using information that shows someone that its goals are not met or processes are not accomplishing what they supposed to, leaders can induce the sense that a group is not living up to its own ideals which creates 'a motivation to change'. This strong focus on the importance of leaders is not only Schein's viewpoint, as the importance of effective leadership in organizational culture has been acknowledged by many authors (e.g. Denison, Hooijberg, Lane, and Lief (2012); Tsai (2011)).

Culture will be defined by what a group has learned from core problems which an organization had to deal with. Schein defines two types of problems: problems of external adaptation, which can be considered as survival in and adaptation to the external environment and problems of internal integration, being the integration of internal processes (e.g. reaching consensus on authority and status) to ensure the capacity to continue to survive and adapt. Keeping Schein's theory in mind, his definition of organizational culture, cited by many authors (e.g. Jespersen, Griffiths, and Wallace (2017)), can be easily understood: "A pattern of shared basic assumptions that was learned by a group as it solved its problems of external adaptation and internal integration, that has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way to perceive, think, and feel in relation to those problems" (Schein (2004)).

Denison (1990), another frequently cited author in the field of organizational culture, describes the process by which organizational culture can influence its performance and effectiveness by four principles or traits. The first one is the 'involvement' principle, which suggests that high levels of involvement and participation can result in creation of a sense of ownership and responsibility, which can then lead to greater commitment to an organization, making certain explicit bureaucratic control systems abundant. The second principle is 'consistency', which can enhance an organization's capacity for coordinated action and allows a more rapid decision process. This can be achieved in case of high consistency, meaning: a high level of normative integration, shared meaning and a common frame of reference. The third trait 'Adaptability' looks at how the organization copes with external contingencies and changes. High adaptability means taking risks and learn from mistakes, which increases on organization's capability and experience at creating change. 'Mission' is the last principle defined by Denison, providing group members with a sense of purpose and meaning, giving stability and direction, with clear goals in mind. Denison (1990) concludes that the most effective organizational cultures comprise all of these elements, i.e. they are adaptive, but also consistent and responsive to involvement of individual employees, however remaining within the context of a strong shared mission.

1.3.3 Safety culture and climate

As illustrated in Figure 1.2, safety culture can be considered as a subcomponent of organizational culture, which studies safety performance (Nyarugwe et al., 2016). According to Morrow, Koves, and Barnes (2014), safety performance refers to various types of safety outcomes, such as safety behaviors (e.g. following procedures) and organizational outcomes (e.g. accident and injury rates). In this research domain, some authors speak of ‘safety culture’ (e.g. Cooper (2000)), others speak of ‘safety climate’ (e.g. Neal and Griffin (2004)); two terms which are often used interchangeably in this research field. Still, in the this doctoral dissertation, these two terms will be defined separately and considered as distinct terms throughout the whole work (vide infra: ‘1.3.4 Culture or climate’).

Neal, Griffin, and Hart (2000) speak of safety ‘climate’ and consider it “a specific form of organizational climate, which describes individual perceptions of the value of safety in the work environment”. Organizational climate is explained as “a multidimensional construct that encompasses a wide range of individual evaluations of the work environment”. They state that the organizational climate shapes the context in which specific evaluations of the importance of safety are made. The concept of safety culture/climate, was first used in a report of the Nuclear Safety Advisory Group (INSAG, 1988), in response to the nuclear incident in Chernobyl in 1986 (Cooper, 2000; Griffith, Livesey, & Clayton, 2010b). The poor safety culture of the organization was identified as an important factor contributing to the incident. Ever since, the concepts safety climate and safety culture are being used in several sectors, especially in so-called ‘high-reliability organizations’, such as aviation (Gill & Shergill, 2004), nuclear (Morrow et al., 2014) and healthcare (Neal et al., 2000) sector, as these organizations need to perform successfully under challenging conditions with very low levels of failure (Gaba, Singer, Sinaiko, Bowen, & Ciavarelli, 2003).

In the following section some facts about safety climate and culture research in the aviation, nuclear and healthcare sector will be discussed. Of course, also for other industries safety culture and climate research is applied (e.g. mining (Parker, Tones, & Ritchie, 2017) and manufacturing (Liu, Huang, et al., 2015)).

Nuclear sector

As already mentioned, upon the nuclear incident in Chernobyl in 1986 the foundations for safety culture research were laid down, as the concept was introduced and spread (Johnston, McDonald, & Fuller, 2017). Furthermore, although not labeled 'safety culture' at the time, investigation of the Three Mile Island nuclear accident in 1979 in Pennsylvania (US) by the US Nuclear Regulatory Commission, led to the recognition of organizational factors as significantly contributing factors to the accident (Morrow et al., 2014). The report stated the following: "The one theme that runs through the conclusions we have reached is that the principal deficiencies in commercial reactor safety today are not hardware problems, they are management problems" (Rogovin, 1980). Both accidents allowed to gain insight in how shared, underlying beliefs and values, features of an organization's safety culture, can influence an organization's safety performance (Morrow et al., 2014). Evidently, nuclear industry can be considered as a high-reliability and high-risk industry, in which the risk can extend far beyond the immediate locality and have an effect on whole continents and over several generations (Reason, 1990). A typical feature for nuclear industry is the fact that, in case of failure, this will often require large outage operations, demanding a safety climate allowing to manage many contractors during a short time period. Another important feature of nuclear safety are the long-term environmental consequences in case of a nuclear disaster, which have forced the nuclear industry to impose strongly demanding safety regulations (Rollenhagen & Westerlund, 2007). Morrow et al. (2014) identified nine key factors for safety culture research in nuclear industry, based on literature and industry specific documents: management commitment, willingness to raise concerns, decision-making, supervisor responsibility for safety, questioning attitude (towards safety issues), safety communication, personal responsibility for safety, prioritizing, safety and training quality. In this study of Morrow et al. (2014) the relationship between safety culture and measures of plant performance (based on, for example, the number of unplanned emergency shutdowns and inspection report findings) was demonstrated. Moreover, the authors suggest that safety culture may be a predictor of future plant performance.

Aviation sector

Aviation is a classic high reliability industry as failures could be catastrophic but are low in rates (Gaba et al., 2003). According to Meshkati (1997), the turning point for 'safety culture' in aviation was the in-flight structural breakup and crash of Continental Express Flight 2574 near Eagle Lakes, Texas, on September 11th, 1991 resulting in 14 killed people. The US National Transportation Safety Board described the cause of the accident as follows: "The failure of Continental Express management to establish a corporate culture which encouraged and enforced adherence to approved maintenance and quality assurance procedures" (NTSB/AAR-92/04, 1992, pg. 54, as cited in Meshkati, 1997), as poor supervision and inspection of the work and communication errors were significant responsible factors (Wiegmann, Zhang, Thaden, Sharma, & Mitchell, 2002). Because of the strong individual responsibilities for the safety of the aircraft laid upon flight crew, who are performing within a corporate setting, fostering certain norms, values and beliefs, the importance of safety culture in aviation industry became clear (Johnston et al., 2017). Ever since, safety culture and climate research in aviation took off and aviation industry has been a leader in the development of a number of human-focused safety programs (e.g. crew resource management) (O'Connor, O'Dea, Kennedy, & Buttrey, 2011). O'Connor et al. (2011) report several studies focusing on assessment of safety climate through questionnaires at different levels. Questionnaires were applied to commercial pilots, cabin staff, ground handlers, aviation maintainers, air traffic controllers, etc. The authors identified three themes in safety culture/climate research which were particularly relevant to aviation. The first theme is 'communication', as in aviation industry, the different occupational groups (vide supra) are not co-located (e.g. cabin personnel versus air traffic control), which can be quite challenging to ensure effective safety communication. A second theme is 'resources', as the availability of resources for safety (e.g. time, money, equipment) appears to become more and more relevant in the current economic climate. The third is dealing with 'commitment of operations personnel to safety'. Due to the fact that aviation industry contains different specialized occupational groups, commitment of the personnel involved in the operations (e.g. cabin crew and pilots) should be stressed and assessed separately according to the study of O'Connor et al. (2011), although many studies state that commitment should be present at all levels of the organization (e.g. Griffith et al. (2010a)). Nevertheless, besides the three specific aviation related themes, as described by O'Connor et al. (2011), most themes considered in aviation are in agreement with safety climate and culture research in other industries: e.g. management (commitment), safety systems (aspects of the organization's safety management system), education and training and risk perception (Flin, Mearns, O'Connor, & Bryden, 2000; O'Connor et al., 2011).

Healthcare sector

Healthcare institutions strive to be high-reliability organizations, as within the intrinsically hazardous modalities of medical care, patients should be treated efficiently and safely (Gaba et al., 2003). Actually, two types of safety can be distinguished, safety towards the patient ('patient safety') and occupational safety towards the healthcare personnel (Gaba et al., 2003). Several authors performed studies related to the impact of safety culture on occupational safety for healthcare personnel with a particular interest related to needlestick exposure to blood borne pathogens such as HIV (Clarke, Rockett, Sloane, & Aiken, 2002; Gaba et al., 2003). Also the relation of organizational and safety culture with patient outcomes for specific diseases was already investigated by several authors (Shortell et al., 2000; Shortell, Rousseau, Gillies, Devers, & Simons, 1991). For example, Larson, Early, Cloonan, Sugrue, and Parides (2000) investigated the relation between organizational culture, frequency of staff handwashing and nosocomial infections associated with methicillin-resistant *Staphylococcus aureus* (MRSA). Neal et al. (2000) provided evidence of the impact of organizational climate on safety climate, and the relation of safety climate with employees' compliance to safety regulations and procedures as well as participation in safety-related activities within the workplace in a study performed in a large Australian hospital. Also the importance of leadership in relation to food safety climate and safety performance of employees is already widely investigated in this sector (Lievens & Vlerick, 2014; Zohar & Luria, 2010).

It can be concluded that safety culture has become an important risk factor and is investigated in case large incidents happen (Griffith et al., 2010b). Some more recent examples of accidents where safety culture was identified as a significantly contributing factor are: the Texas City refinery explosion in 2005, the Washington Metropolitan Area Transit Authority rail collision in 2009, the Deepwater Horizon oil spill in 2010, the Upper Big Branch mine explosion in 2010 and the Fukushima nuclear accident in 2011 (Morrow et al., 2014).

1.3.4 Culture or climate

Important to discuss and to clarify in this introduction is the use of the terms 'culture' and 'climate', as both concepts are often used interchangeably in literature.

Denison (1996) studied differences between organizational culture and climate and states that, on the surface, culture is able to capture evolutions over time and is about understanding underlying assumptions, using generally qualitative methods, whereas climate is not focusing on evolution of a social system over time, but rather on the impact on individuals and groups. Furthermore, climate is linked to perceptions of 'observable' nature and categorization of these perceptions in measurable dimensions. The author states that the most significant difference is in the theoretical traditions coming from other branches of social sciences, as climate is sprouting from the Lewinian logic, in which it is posited that the individual can be analytically separated from the environment. On the other hand, culture originates from social constructionism in which this analytical separation is deemed impossible. Still, Denison (1996) argues that the difference between climate and culture is rather a difference in interpretation than in the phenomenon, as both climate and culture are addressing the phenomenon of "the creation and influence of social contexts in organizations". Therefore, the author suggests that both perspectives could be complementary and proposes an integration of climate and culture research approaches.

Wiegmann et al. (2002); (2004) studied publications defining safety climate and culture in several industries, such as, for example, aviation (Flin et al., 2000), manufacturing (Cheyne, Cox, Oliver, & Tomas, 1998) and construction (Dedobbeleer & Beland, 1991), and found three commonalities in which safety climate differs from safety culture wich are largely in line with differences identified by Denison (1996). Firstly, the authors state that "safety climate is a psychological phenomenon, usually defined as the perceptions of the state of safety at a particular time". Secondly "safety climate is closely concerned with intangible issues such as situational and environmental factors" and thirdly, "safety climate is a temporal phenomenon, a snapshot of safety culture, relatively unstable and subject to change".

Indeed, safety climate is commonly defined as the relative priority or meaning of safety in an organization or work unit as perceived by employees. It originates in individual perceptions and is derived through workers making sense of or ascribing meaning to their work environment (Zohar, 2011). As these perceptions become shared when they converge among workers in the same work unit or organization, one can measure safety climate not only at an individual level but also at a group level, proposing safety climate as a shared perception among employees, which is a collective phenomenon (Zohar, 2011). This view was followed in the present doctoral dissertation in which climate is considered as the employees' perception of the situation within an organization, a 'snapshot' that reflects important aspects of an organization's safety culture (Neal et al., 2000). Culture can be considered as the bigger framework, of which climate is a component. (Safety) culture is seen as serving an overarching, sense-making context for the creation and maintenance of perceptions, attitudes and beliefs across factors of a more temporal character (Zohar, 2011).

Schein (2017) considers climate as an artifact or a manifestation of culture; the product of some of the underlying assumptions of culture. This view can be considered partly in line with the view used in this manuscript (see below), as perceptions can be seen as a manifestation of culture.

1.4 Food safety culture

1.4.1 Ensuring food safety: from technology to culture

Ensuring food safety has evolved tremendously in the last decades. Initially, introduction of food processing and preservation technologies created possibilities for mitigation, control and prevention of (microbiological) hazards. Major breakthroughs were for example the use of pasteurization and sterilization (e.g. Holsinger, Rajkowski, and Stabel (1997) and Josephson (1981)) and application of additives (e.g. Gould (1996), modified atmosphere packaging (e.g. Ellis, Smith, Simpson, Ramaswamy, and Doyon (1994)) and cooling techniques (e.g. Tholozan et al. (1998)) to extend the shelf life of food products. In the period 2000-2010 harmonized and risk-based (European) legislation laid down new principles in the control of food safety, and major investments were made by food (processing) companies for the implementation of FSMSs based on good practices and hazard analysis and critical control point principles (Mensah & Julien, 2011; Tomasevic et al., 2013). Scientific research followed a similar course: from more technological aspects (Farber, 1991; Gould, 1996), over research related to sampling plans and analytical capacity for control of processes and products (Jacxsens et al., 2009; Vellaisamy, Sankar, & Taniguchi, 2003), to research related to the development and implementation of FSMSs (Armstrong, 1999; Mensah & Julien, 2011; Milios, Drosinos, & Zoiopoulos, 2012; Vladimirov, 2011). Further, tools were developed to assess the effectiveness of the implemented FSMSs (e.g. Jacxsens et al. (2015); Kafetzopoulos and Psomas (2013), see Table 1.1 and Appendix 1.A). Most (European) companies participating in these studies managed to have fit-for-purpose and well elaborated quality assurance and quality control systems in place (Luning et al., 2015).

Despite the efforts to develop and implement FSMSs, consumer food poisoning and outbreaks are still reported and remain an important source of human disease (EFSA, 2014; Griffith, 2006). Many of these incidents can be traced back to food handler errors and/or non-compliance with food hygiene or food safety procedures (Powell et al., 2011; Wright, Leach, & Palmer, 2012) (see section 1.2). Few authors already noticed this problem, shifting the focus from a formal and technical oriented FSMS to a more human dimension of food safety as reflected by the introduction of concepts such as food safety culture and food safety climate (Gilling, Taylor, Kane, & Taylor, 2001; Griffith et al., 2010a; Powell et al., 2011; Taylor, 2011; Yiannas, 2009) and by using behavioral and psychological models and methods in the field of food safety (e.g. Gilling et al. (2001)). For example, Taylor and Taylor (2004) applied qualitative psychology (four in-depth narrative interviews) in the identification of the barriers for HACCP implementation. The same research question was investigated by Gilling et al. (2001) making use of knowledge of behavioral adherence models used in medical research to identify barriers for adherence to or compliance with a system or guideline. Another example is the study of Clayton and Griffith (2008), in which the Theory of Planned Behavior model was used to predict caterer's hand hygiene practices. According to this theory of planned behavior, attitudes toward behavior, subjective norms, and perceived behavioral control, together significantly influence an individual's behavioral intentions and behaviors (Ajzen, 1991).

The trend towards increased interest for the human dimension in food safety parallels the accumulating empirical evidence of the key impact of the organizational culture and climate on employees' decision making and behavior (e.g. the actual adequate execution of procedures), and safety outcomes in several other industrial settings such as nuclear (Morrow et al., 2014), aviation (Gill & Shergill, 2004), and healthcare sector (Neal et al., 2000), as illustrated in section 1.3.3.

A similar evolution can be noticed in these occupational health and safety (also called 'workplace health and safety') research domains (Wiegmann et al., 2002). Theories of accident causation have developed through different stages to identify root causes of failure in these 'high risk systems' (Wiegmann et al., 2002). Wiegmann and Shappell (2001) define the first stage as the 'technical period', as new mechanical equipment was rapidly developing and most accidents were caused by malfunctions in design and construction of this technical equipment (CDC, 1997; Wiegmann & Shappell, 2001). In a second stage, focus was on appropriate procedures and risk management strategies to ensure safety at the work place (Wright et al., 2012). In a third stage, attention shifted to human error and cognitive shortcomings of operators and later on also interactions of human and technical factors were studied (Wiegmann et al., 2002). And finally, the (organizational) culture period emerged, recognizing that operators are not performing in isolation but as a member of a coordinated team of employees, embedded in a particular culture (Singer et al., 2007).

As this evolution in occupational health and safety contexts took place several years before the concept 'food safety culture' emerged, safety culture/climate research in these occupational health and safety contexts is already widely studied and a lot of knowledge is already established concerning the link between safety climate/culture and human behavior (Wright et al., 2012) (see section 1.3.3). Food scientists can take advantage of and build upon the insights already gained in these non-food contexts in establishing food safety culture research.

1.4.2 Food safety culture and climate: definitions and conceptual model

As a first step in this interdisciplinairy research, discussions were organized between experts in the field of organizational and safety climate and culture, from the Faculty of Psychology and Educational Sciences, and experts in food safety management, from the Faculty of Bioscience Engineering.

Several definitions of safety culture and safety climate were studied. For example, a frequently cited definition is the definition of Neal et al. (2000) (see section 1.3.4), who consider safety climate as "a specific form of organizational climate, which describes individual perceptions of the value of safety in the work environment". Also the definition of Griffith et al. (2010b), which is considered as the first 'food' safety culture definition, was discussed. The author defines food safety culture as "the aggregation of the prevailing, relatively constant, learned, shared attitudes, values and beliefs contributing to the hygiene behaviors used within a particular food handling environment" (Griffith et al., 2010b). From a bioscience engineering perspective, the latter definition might miss some tangibility and the question might rise, how to measure this phenomenon. Also Griffith et al. (2010b) sought to represent this concept in a more tangible and measurable way, as in their next paper (Griffith et al., 2010a), the authors propose dimensions of food safety culture, allowing to measure food safety culture in companies (see Table 1.4). Therefore, based on expert discussions the objective was set to develop a conceptual model of food safety culture, with more tangible and measurable elements.

Firstly, starting from the well-established research about the techno-managerial approach in food safety management at the Department of Food Technology, Safety and Health (Faculty of Bioscience Engineering) in collaboration with Wageningen University (e.g. Luning, Jacxsens, et al. (2011), see section 1.1.3), *'a techno-managerial route'* was proposed (Figure 1.3). In this *'techno-managerial route'* the FSMS and its performance play a key role (Luning & Marcelis, 2009). The available technology, the context in which the company is operating and the company characteristics determine the risk level of the company and will therefore influence the performance of the FSMS of the company (Luning, Marcelis, et al., 2011a). Indeed, previous research revealed that the FSMS should be tailored to the risk level of the context of a food company in order to be able to reach a satisfying safety, hygiene or quality level of processed foods (Luning et al., 2015; Luning, Marcelis, et al., 2011a). For example, the context riskiness of a meat processing company will be higher than the riskiness of a company producing dry cookies, as, among others, the raw material (e.g. raw meat) and final product in the meat processing company is more susceptible to contamination with foodborne pathogens. As a consequence, a higher level of control activities (e.g. monitoring of temperature to maintain cold chain) and assurance activities (e.g. increased documentation and record keeping) will be required. Based on the expert discussion, it was concluded that the techno-mangerial route also plays a role in shaping an organization's food safety culture, as e.g. setting (formal) food safety objectives is part of the organization's FSMS. Moreover, also Griffith et al. (2010a) propose 'management systems and style' (Table 1.4) as one of the dimensions of food safety culture.

Secondly, a *'human route'* is proposed, in which the food safety climate plays a key role (see Figure 1.3). As stated in section 1.3.4, food safety climate can be considered as the employees' perception of the situation within an organization, a 'snapshot' that reflects important aspects of the organization's food safety culture. Referring to Schein's view (see 1.3.4), stating that climate is the product of some of the underlying assumptions of culture, climate can be considered as an artifact of culture, representing the tip of the iceberg of culture, being the part that is observable or measurable. In this research, these 'products' or 'manifestations' of the underlying assumptions of culture are considered as the perceptions of employees throughout the organization about the organiation's food safety culture.

We propose that both routes can influence the output, i.e. the level of food safety and hygiene of final delivered or processed food products (e.g. presence or absence of foodborne pathogens, concentration of hygiene indicators such as *E. coli* and quality parameters such as lactic acid bacteria, total count) (see Figure 1.3). Furthermore, as suggested by several authors (e.g. Nyarugwe et al. (2016)), an interplay between both routes is considered. For example, within the FSMS, the management of the company sets organizational goals and policies, which can reflect perceptions of the management about the priority and value of food safety in the company (human route influences techno-managerial route) (Griffith et al., 2010a). And these policies, as part of the FSMS, in turn, might influence how employees perceive the importance of food safety in their daily work (techno-managerial route influences human route) (Griffith et al., 2010a).

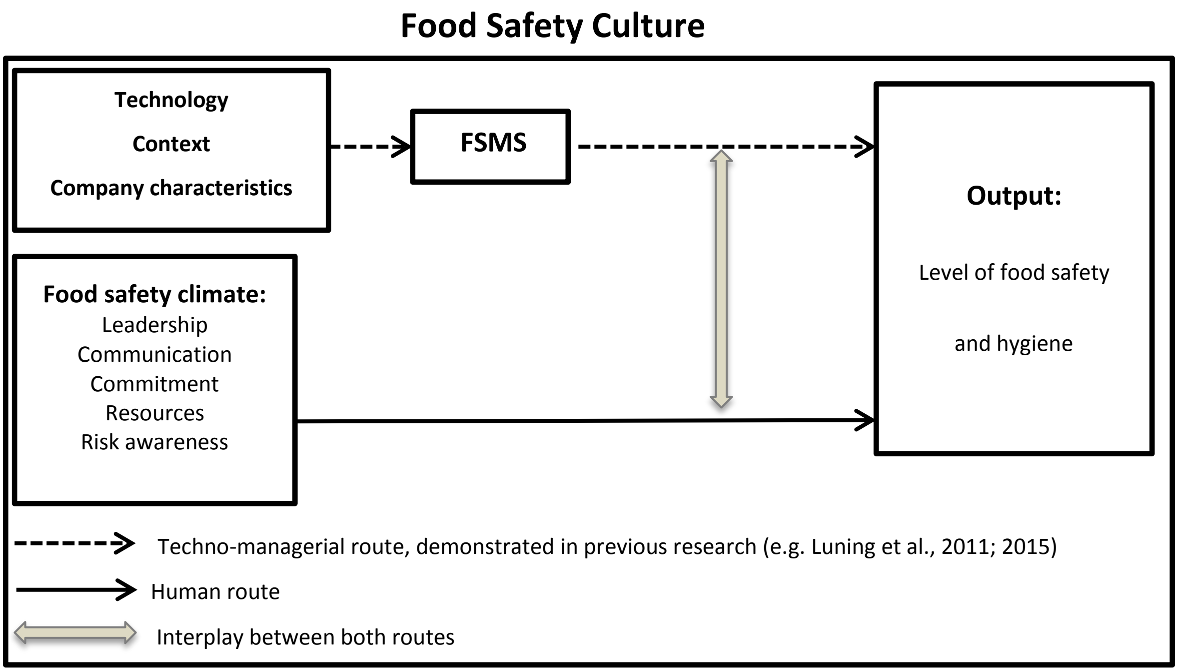

Figure 1.3: Food safety culture: basic conceptual model developed and explored in this doctoral dissertation

Summarized, according to this model, food safety culture can be defined as the interplay of the food safety climate as perceived by employees and management at all levels of a company (so called *'human route'*) and the implemented FSMS, which will be influenced by the available technology, company characteristics and the context of the company (so called *'techno-managerial route'*), resulting in a certain level of food safety and hygiene of the final food products. As food safety climate is considered as the perception of employees reflecting a snapshot of the safety culture (vide supra), these perceptions can be measured. In order to be able to assess food safety climate, first, possible components of food safety culture, as described in literature, are explored. In chapter 2, a food safety climate assessment tool is presented allowing to measure perceptions of these components.

Based on available publications dealing with food safety culture or climate at the beginning of this doctoral research (published before 2014) (Table 1.4), components of food safety culture and climate as proposed by the different authors were compared and discussed. This revealed that authors distinguish and describe to a great extent similar variables, which are often based on organizational and safety culture research. Five overarching food safety culture components could be identified, largely in agreement with the components identified by Griffith et al. (2010a). These components are included in our conceptual model (Figure 1.3) as food safety 'climate' components, as in the following chapter perceptions about these factors will be assessed.

Table 1.4 : Overview of available publications (before 2014) proposing components for food safety culture

Author	Components
Yiannas (2009)	Leadership; Confidence of the employees; Clear management visibility and leadership; Accountability at all levels; Sharing knowledge and information
Griffith et al. (2010a)	Management systems and style; Leadership; Communication; Commitment; Environment; Risk
Taylor (2011)	Knowledge (awareness, expertise, training…); Attitude/psychological factors (risk awareness, motivation, self-efficacy…); Behavioral factors (resources, competence, FSMS…); External factors (government/industry guidelines, inspections/audits…)
Wright et al. (2012)	Organization priorities and attitudes; Organization's perception and knowledge; Organization's confidence in food hygiene requirements; Organization ownership of food safety and hygiene; Competence, learning and training; Leadership; Employee engagement; Communications and trust
Abidin (2013)	Management support and commitment; System and process (procedures, communication, resources…); Employee attitude and behavior

Griffith et al. (2010a) mention **leadership** as first food safety climate component. Leadership is defined as the perception of the extent to which the organization's leader(s) are able to engage staff in hygiene/safety performance and compliance to meet the organization's goals/vision/standards concerning hygiene and food safety. The second component is **communication**, which is the perception of the extent of transfer or diffusion of hygiene and food safety related information within the organization. A third component deals with **commitment** and is defined as the perception of the extent of engagement and involvement concerning hygiene and food safety of all parties within the organization. It should be noted that commitment is a multidimensional construct and that an individual can develop multiple work-relevant commitments at different levels, e.g. commitment to job tasks, the team, organizations (Meyer & Herscovitch, 2001). In this doctoral disseration, commitment to hygiene and food safety is considered, although this may influence commitment towards, for example, certain job tasks. As a fourth component **resources** was defined as the perception of the extent to which physical and non-physical means, necessary to operate in a hygienic and food safe way, are present in the organization (e.g. time, personnel, infrastructure, education/training and procedures). The last component in food safety climate, is **risk awareness**, being the perception of the extent to which the organization is aware of the risks concerning hygiene and food safety and has these under control.

Consequently, food safety climate could be defined as employees' (shared) perception of leadership, communication, commitment, resources and risk awareness concerning food safety and hygiene within their current work organization. This definition will be applied further in this work.

1.5 Conclusion

In the time period 2000 - 2015 many legal documents and guidelines, on international, European and national level resulted in the development and implementation of FSMSs, as a system consisting of PRPs, HACCP based procedures and other principles laid down in the General Food Law (EC, 2002) or 'General Principles on Food Hygiene' (CAC, 2003), to manage food safety and hygiene in food businesses along the agro-food chain. As such, scientific research focus was mainly on e.g. analytical methods, food processing technology and sampling plans, supporting FSMS fundaments. Also barriers for implementation and methods for performance assessment of FSMSs are widely described in literature.

However, in practice, a well elaborated and 'fit for purpose' FSMS, does not always guarantee the highest level of food safety and hygiene, as foodborne outbreaks still occur and remain an important source of human disease, especially in case of microbiological hazards. Many of these incidents can be traced back to food handler error or non-compliance with food hygiene and safety procedures (e.g. handwashing practices), suggesting the importance of human behavior (e.g. the actual execution of procedures), and decision making in improving the hygiene and safety status of food products along the food supply chain. Building upon a similar evolution in occupational health and safety research, food safety culture and climate were introduced, mirroring the human dimension in food safety management.

In this introductory chapter, a framework was set and definitions for food safety culture and climate were developed. Summarized, based on the proposed conceptual model, food safety culture can be defined as the interplay of the food safety climate as perceived by employees and management at all levels of a company (so called *'human route'*) and the implemented FSMS, which will be influenced by the available technology, company characteristics and the context of the company (so called *'techno-managerial route'*), resulting in a certain level of food safety and hygiene of the final food products. Food safety climate, being a constituent of food safety culture, is defined as employees' (shared) perception of leadership, communication, commitment, resources and risk awareness concerning food safety and hygiene within their current work organization. These definitions for food safety climate and food safety culture will be applied throughout the whole doctoral dissertation. Also the conceptual model, as presented in Figure 1.3, will be used as an overarching model.

Chapter 2

Food safety climate in food processing organizations: development and validation of a self-assessment tool

Redrafted from:

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Abstract

The aim of this chapter was to develop and validate a tool to assess the food safety climate in food companies. Based on available literature and expert discussions, five to six indicators/statements were defined for each of the food safety climate components, being leadership, communication, commitment, resources and risk awareness. Respondents can express the extent to which they agree with the statements by means of a five-point Likert based answer scale (1→ 5: 'totally disagree', 'disagree', 'nor agree, nor disagree', 'agree', 'totally agree'). The tool was then validated by experts, resulting in a food safety climate self-assessment survey composed of 28 indicators/statements. The practical use was demonstrated through a pilot study in the meat industry. The proposed tool enables food companies to go beyond traditional food safety management based on technological and managerial approaches, and mirrors the human dimension in food safety.

2.1 Introduction

Similar to research in an occupational health and safety context, an increased interest in the human dimension of food safety emerges. More specific, investigating the relation between organizational culture and climate and employees' decision making and behavior related to food safety, might help to understand how food handler errors and/or non-compliance with food safety procedures occur and can be reduced. Furthermore, as many incidents of food poisoning and outbreaks could be traced back to these human errors or non-compliances (see Table 1.3a, b and c), several scientists in the area of food safety (e.g. Griffith et al. (2010a)) made the leap towards this human dimension of food safety by exploring food safety culture and climate.

In chapter 1, a conceptual model and definitions for food safety culture and climate were proposed. Food safety culture was defined, as illustrated in the conceptual model (Figure 1.3), as the interplay of the food safety climate as perceived by employees and management at all levels of a company (so called 'human route') and the implemented FSMS, which will be influenced by the available technology, company characteristics and the context of the company (so called 'techno-managerial route'), resulting in a certain level of food safety and hygiene of the final food products. Food safety climate, being a constituent of food safety culture, is defined as employees' (shared) perception of leadership, communication, commitment, resources and risk awareness concerning food safety and hygiene within their current work organization.

The growing interest in this human dimension of food safety has led to the development of several tools to measure food safety culture/climate in organizations. For example consultancy agency Greenstreet Berman, commissioned by the Food Standards Agency in UK, developed a survey with open questions to be completed by inspectors of local authorities (Wright et al., 2012). A food safety culture audit 'culture excellence' is proposed by Taylor Shannon International for the food industry, giving insights in strengths and weaknesses of the organizational culture (TSI, 2015). Jespersen, Griffiths, Maclaurin, Chapman, and Wallace (2016) introduced a food safety maturity model, using self-assessment surveys linked to specific pinpointed behaviors. And a self-assessment survey for catering activities was presented by Abidin (2013). The current chapter describes the development and expert validation of a food safety climate self-assessment tool with indicators for food processing companies, allowing companies to capture employees' perceptions about leadership, communication, commitment, availability of resources and the risk awareness related to food safety in the organization. Furthermore, the tool was applied in a pilot study in butcher shops to demonstrate its potential capacities.

2.2 Developing a food safety climate self-assessment tool

Starting from the definition of food safety climate, as proposed in section 1.4.2, a food safety climate self-assessment tool was developed. Based on scientific and grey literature search and after interdisciplinary discussions between scientists of the Department of Food Technology, Safety and Health (two experts in food safety management) and the Department of Personnel management, Work and Organizational Psychology (two experts in the field of human resources/occupational health and two experts in the diagnosis and development of organizational culture and climate) of Ghent University, five to six indicators (questions) for each of the food safety climate components (leadership, communication, commitment, resources and risk awareness) were developed.

In total 27 indicators divided over the five components were identified to form the preliminary questionnaire (see Tables 2.1-2.5). It should be noted that this tool is not an audit tool nor an inspection tool for third party audits or competent authorities. The tool is designed as a self-assessment survey, which employees of a company can fill out. This survey enables a company to identify how the company's climate concerning hygiene and food safety is perceived by their employees.

As the food safety climate construct stems largely from the idea that employees ascribe meaning to their work environment and have food safety related perceptions of the situation within their organization, we deliberately opted to develop a self-reported measure and asked respondents to evaluate each indicator by means of a five-point Likert answer scale (1→ 5: totally disagree, disagree, neutral, agree, totally agree). This choice is in line with the widespread use of self-report questionnaires in scientific literature. For instance, Ko (2013) and Verhoef, Gutierrez, Koopmans, and Boxman (2013) assessed food safety knowledge and behavior by means of a self-reported survey and Jevsnik, Hlebec, and Raspor (2008) also assessed the perception of food safety issues in the organization by self-reporting. Still, the use of self-report scales might entail certain biases, such as social desirability bias and optimistic bias. The first refers to the tendency of respondents to respond socially desirable. Jespersen, MacLaurin, and Vlerick (2017) developed a self-assessment survey allowing to assess social desirability. However, including these social desirability items in the self-assessment survey, would increase the survey length, which could result in a significant decrease in participation and response quality (Bogen & Amer Stat, 1996). Optimistic bias is considered as one of the most consistent, prevalent and robust biases in psychology and can be defined as "a psychological phenomenon in which people believe they are less likely to experience negative events and more likely to experience positive events than others" (Rossi, Stedefeldt, da Cunha, & de Rosso, 2017; Sharot, 2011). Also for this type of bias self-assessment scales exist, albeit rather in the context of assessing perceptions about personal health risks. Another approach might be to measure actual outcomes or objective criteria to assess optimistic bias. However, these studies are lacking (Klein & Weinstein, 1997).

The indicators and answer scale of our food safety climate self-assessment tool were constructed in a way that a higher score on the answer scale (higher agreement with statements) corresponds with a better perceived food safety climate in the company. However, it should be noted that consequences related to the different category descriptions in this qualitative scale may not be linear, as differences between the categories imply different food safety consequences. So, no linear relation can be assumed between category scores and food safety consequences.

2.2.1 Indicators for food safety climate component leadership

Organizations with better leaders are more productive, competitive and responsive (Griffith et al., 2010a). Moreover, an organization's climate starts at the top and flows downward (Yiannas, 2009). Therefore, it is not sufficient to have a strong management, also strong leaders are necessary. Maxwell (1998) states that "the main difference between leadership and management is that leadership deals with influencing people to follow, while management focuses on maintaining systems and processes." Hence, leaders should be able to '*motivate employees'* (L3) to work in a hygienic and food safe way. As such, this statement was introduced as an indicator in our food safety climate assessment tool (see Table 2.1). '*Setting of clear objectives concerning food safety and hygiene'* (L1) was also included. Setting objectives enables the measurement of performance (against the objectives) and is therefore a first step towards continuous improvement (Yiannas, 2009). Furthermore, strong leaders '*set clear expectations towards the employees'* (L2), making sure that every employee in the organization knows exactly what is expected from him/her concerning food safety and hygiene and what he/she needs to do to achieve this expectancy (Yiannas, 2009). As employees on the work floor are daily confronted with hygiene and food safety practices, they are often first to notice deviations and to expose problems and opportunities. Because of this, it can be beneficial for leaders to '*listen to employees*, *if they have remarks or comments concerning hygiene and food safety'* (L4). Moreover, employees will feel more involved and motivated if they perceive that their opinion matters (Yiannas, 2009). The indicator (L4) is based on the psychosocial safety climate scale (PSC-12) (Hall, Dollard, & Coward, 2010) and was adapted to a food safety context by replacing 'occupational health and safety' by 'hygiene and food safety'. Another indicator for leadership deals with the fact that remarks concerning food safety and hygiene issues should be '*constructive and respectful'* (L5) in order to avoid a blame culture, in which employees are discouraged to admit their mistakes because of the possible consequences. In case of a blame culture, the potential underlying reason cannot be solved (Griffith et al., 2010a; Reason, Carthey, &

de Leval, 2001). The above mentioned five indicators of the component leadership are included in the initial version of our tool (see Table 2.1).

Table 2.1: Indicators of component leadership of the food safety climate self-assessment tool. Respondents can answer by means of a five-point Likert scale (1→ 5: totally disagree, disagree, neutral, agree, totally agree)

	Leadership
L1	In my organization, the leaders set clear objectives concerning hygiene and food safety.
L2	In my organization, the leaders are clear about the expectations concerning hygiene and food safety towards employees.
L3	In my organization, the leaders are able to motivate their employees to work in a hygienic and food safe way.
L4	In my organization, the leaders listen to employees, if they have remarks or comments concerning hygiene and food safety.
L5	In my organization, hygiene and food safety issues are addressed in a constructive and respectful way by the leaders.
L6[a]	In my organization, the leaders strive for a continuous improvement of hygiene and food safety.

[a] indicator added after the expert validation

2.2.2 Indicators for food safety climate component communication

The culture in an organization is influenced by the leader-member exchange (LMX). This concept is a measure for the quality of the social exchanges between employees and leaders (Flin & Yule, 2004; Griffith et al., 2010a). A high LMX can lead to a better engagement in communication concerning hygiene and food safety. This way, employees will be more concerned with hygiene and food safety (Hofmann & Morgeson, 1999). The indicator *'regular communication with operators'* (C1) was retained, as leaders should communicate regularly with the employees in order to make sure that employees know their roles and responsibilities (see Table 2.2). Also, objectives, values and beliefs concerning food safety can be transferred by regular communication (Yiannas, 2009). Regular repetition is required to remind employees of the importance of hygiene and food safety. This indicator focuses on the time aspect.

Communication from leaders should also be clear and understandable, and adapted to the educational level of the receiver. This statement also means that the appropriate language should be used and that additional effort is spent to make sure that hygiene and food safety messages are clear to employees who do not share the same primary language (Taylor, 2011). For this reason indicator C2 '*leaders communicate in a clear way with the operators'* was added to the tool (see Table 2.2). A high LMX also means that communication from operator to leader is possible. If food handlers feel that they can speak freely about hygiene and food safety related matters with their leaders, this will contribute to the openness of the organization and might be beneficial for the food safety climate (Griffith et al., 2010a; Hofmann & Morgeson, 1999). Therefore, indicator C3 *'it is possible for operators to communicate with leaders'* was introduced. Employees should also feel free to approach colleagues which are engaged in behavior that can be harmful for hygiene and food safety and to openly discuss about hygiene and food safety issues with their colleagues, which can lead to a higher level of hygiene and food safety (Griffith et al., 2010a). This idea led to the inclusion of indicator C5 '*I can discuss problems concerning hygiene and food safety with colleagues'.* Indicator C4 '*the importance of hygiene and food safety is permanently present by means of, for example, posters, signs and/or icons related to hygiene and food safety*' was included as Yiannas (2009) states that if employees are constantly reminded of the importance of hygiene and food safety, they will be more inclined to adopt this belief. Furthermore, the use of multiple mediums to carry out hygiene and food safety messages can increase effectiveness (Yiannas, 2009). Some possible examples are the indication of critical control points in the organization by signs and messages for hand washing at washing facilities. Each of the above mentioned five indicators are included in the self-assessment tool for the component communication (see Table 2.2).

Table 2.2: Indicators of component communication of the food safety climate self-assessment tool. Respondents can answer by means of a five-point Likert scale (1→ 5: totally disagree, disagree, neutral, agree, totally agree)

	Communication
C1	In my organization, the leaders communicate regularly with the operators about hygiene and food safety.
C2	In my organization, the leaders communicate in a clear way with the operators about hygiene and food safety.
C3	In my organization, it is possible for the operators to communicate about hygiene and food safety with the leaders.
C4	In my organization, the importance of hygiene and food safety is permanently present by means of , for example, posters, signs and/or icons related to hygiene and food safety.
C5	I can discuss problems concerning hygiene and food safety with colleagues in my organization.

2.2.3 Indicators for food safety climate component commitment

The indicator *'leaders clearly consider hygiene and food safety to be of great importance'* (E1) is based on the psychosocial safety climate (PSC-12) scale and was adapted to a food safety context (Hall et al., 2010) (see Table 2.3). Leaders must demonstrate that hygiene and food safety are important; more important than for example productivity and saving money (Griffith et al., 2010b). This notion should be ingrained in the company culture. Furthermore, if employees' own beliefs and values concerning hygiene and food safety align with those of the organization, they will be more motivated and exceed expectations, because they do not see it merely as their task, but believe in it themselves (Griffith et al., 2010a). This statement led to the inclusion of indicator E2 '*my colleagues are convinced of the importance of hygiene and food safety'.* Indicator E3 '*working in a hygienic and food safe way is recognized and rewarded*' is dealing with the consequences of certain behavior (Table 2.3). Consequences determine whether a behavior is repeated. Especially positive consequences stimulate good behavior. Negative consequences are less effective in influencing long-term behavioral change and rather work on a short term (Yiannas, 2009). Leaders should motivate their employees, give positive feedback and acknowledge good behavior. In this way, employees are stimulated to work in a hygienic and food safe way (Griffith et al., 2010a; Yiannas, 2009).

Also, leaders should '*set a good example concerning hygiene and food safety'* (E4), as actions of leaders will be adopted by the employees (Griffith et al., 2010a). Moreover, if leaders participate in the critical everyday tasks, demonstrating the importance of hygiene and food safety, employees will pay more attention to hygiene and food safety themselves. The leaders should also participate in education and training related to hygiene and food safety (Wiegmann et al., 2002). Indicator E5 '*leaders act quickly to correct problems/issues that affect hygiene and food safety'* is based on the psychosocial safety climate (PSC-12) scale and was adapted to a food safety context (Hall et al., 2010). This indicator investigates whether the leaders are committed to ensure hygiene and food safety and consider this a priority.

Indicator E6 '*employees are actively involved by the leaders in hygiene and food safety'* also originates from the psychosocial safety climate (PSC-12) scale and was also adapted to a food safety context (Hall et al., 2010). If employees recognize that they have a critical role in the hygiene and food safety of the product, they will be motivated to work in a hygienic and food safe way. They will also feel proud about good food safety results of the organization (Griffith et al., 2010a). For the component commitment, these six indicators are retained in the proposed self-assessment tool (see Table 2.3).

Table 2.3: Indicators of component commitment of the food safety climate self-assessment tool. Respondents can answer by means of a five-point Likert scale (1→ 5: totally disagree, disagree, neutral, agree, totally agree)

	Commitment
E1	In my organization, the leaders clearly consider hygiene and food safety to be of great importance.
E2	My colleagues are convinced of the importance of hygiene and food safety for the organization.
E3	In my organization, working in a hygienic and food safe way is recognized and rewarded.
E4	In my organization, the leaders set a good example concerning hygiene and food safety.
E5	In my organization, the leaders act quickly to correct problems/issues that affect hygiene and food safety.
E6	In my organization, employees are actively involved by the leaders in hygiene and food safety related matters.

2.2.4 Indicators for food safety climate component resources

If '*employees get sufficient time to work in a hygienic and food safe way*' (M1), they will sense that there is a lot of support (financial, practical, psychological and emotional) for hygiene and food safety related issues from the organization (perceived organizational support) (see Table 2.4). This sense can lead to a higher motivation to work in a hygienic and food safe way (Griffith et al., 2010a). Also, if employees do not have to work under pressure, this can lead to final products of higher quality and safety. High perceived organizational support also means that '*sufficient staff is available to follow up hygiene and food safety*' (M2), so that every staff member gets sufficient time to work in a hygienic and food safe way. Also, replacements of staff should be possible in case of sickness or leave.

Organizational support is also reflected by the availability of the '*necessary infrastructure (e.g. good work space, good equipment,…) to work in a hygienic and food safe way*' (M3) and *'sufficient financial resources to support hygiene and food safety (e.g. lab analyses, external consultants, extra cleaning, purchase equipment…)'* (M4). Indicator M5 *'sufficient education and training related to hygiene and food safety is given'* was included, as frequent education and training concerning hygiene and food safety is needed in order to achieve behavioral change. Education is more related to the transfer of knowledge and information and deals with 'why' hygienic practices and food safety are important. Education usually takes place in a class room setting. Training deals with 'how' tasks should be executed to guarantee hygiene and food safety. By a more specific on-site demonstration employees are taught how they can execute their tasks in a hygienic and food safe way (Yiannas, 2009). '*Good procedures and instructions concerning hygiene and food safety are in place*' (M6) was also identified as an indicator for component commitment, as procedures and instructions should be present, written down and documented, to make sure that employees clearly know what is expected from them and in order to prevent deviations and doubts about certain procedures or instructions (Yiannas, 2009). Each of the above described six indicators are included in the self-assessment tool for the component resources (see Table 2.4).

Table 2.4: Indicators of component resources of the food safety climate self-assessment tool. Respondents can answer by means of a five-point Likert scale (1→ 5: totally disagree, disagree, neutral, agree, totally agree)

	Resources
M1	In my organization, employees get sufficient time to work in a hygienic and food safe way.
M2	In my organization, sufficient staff is available to follow up hygiene and food safety.
M3	In my organization, the necessary infrastructure (e.g. good work space, good equipment...) is available to be able to work in a hygienic and food safe way.
M4	In my organization, sufficient financial resources are provided to support hygiene and food safety (e.g. lab analyses, extern consultants, extra cleaning, purchase equipment…).
M5	In my organization, sufficient education and training related to hygiene and food safety is given.
M6	In my organization, good procedures and instructions concerning hygiene and food safety are in place.

2.2.5 Indicators for food safety climate component risk awareness

Indicator R1 *'the risks related to hygiene and food safety are known'* was added as risk perception and the subsequent risk taking behavior is of great importance for a good food safety climate (Griffith et al., 2010a) (see Table 2.5). Risks should be known by the employees, so they can take them into account in their daily work decisions. The second indicator *'the risks related to hygiene and food safety are under control'* (R2) reflects whether management and employees feel they can rely on and trust the performance of the organization's food safety management system. The atmosphere will be less stressful and employees will feel that the organization is doing a good job. This trust can be motivating to remain committed to hygiene and food safety (Zhu & Akhtar, 2014).

However, this may not lead to blindly trust. Indicator R3 *'my colleagues are alert and attentive to potential problems and risks related to hygiene and food safety'* is a measure for the overconfidence of employees concerning hygiene and food safety issues and the underestimation of the food safety risks (Griffith et al., 2010a). On the other hand, if employees think that the leaders overestimate and exaggerate the risks concerning hygiene and food safety, they will be less inclined to operate in a hygienic and food safe way. Therefore indicator R4 *'the leaders have a realistic picture of the potential problems and risks related to hygiene and food safety'* was included in the tool. Good risk communication is essential to make sure that not only the leaders but also the employees have a realistic picture of the potential risks concerning hygiene and food safety in the organization and act accordingly (Griffith et al., 2010a). This statement led to the inclusion of indicator R5 *'the operators have a realistic picture of the potential problems and risks related to hygiene and food safety'*. In the study of van Achterberg et al. (2011) in a health care setting, risk communication was identified as an effective technique to achieve behavioral change. Risk communication of the leaders can therefore influence employees' risk awareness and how employees will act concerning hygiene and food safety. Each of the above described five indicators are included in the self-assessment tool for the component risk awareness (see Table 2.5).

Table 2.5: Indicators of component risk awareness of the food safety climate self-assessment tool. Respondents can answer by means of a five-point Likert scale (1→ 5: totally disagree, disagree, neutral, agree, totally agree)

	Risk awareness
R1	In my organization, the risks related to hygiene and food safety are known.
R2	In my organization, the risks related to hygiene and food safety are under control.
R3	My colleagues are alert and attentive to potential problems and risks related to hygiene and food safety.
R4	In my organization, the leaders have a realistic picture of the potential problems and risks related to hygiene and food safety.
R5	In my organization, the operators have a realistic picture of the potential problems and risks related to hygiene and food safety.

2.3 Expert validation of the food safety climate assessment tool

As experts in the diagnosis and development of organizational culture and climate in general were already involved in the conceptualization phase of our study (see above) and we aimed to validate our preliminary tool in a food safety context by experts who are familiar with the food industry, they were not further consulted in this expert validation research phase. Twenty experts, not involved in the development of the preliminary tool, with expertise in food safety/quality and food safety management systems in food companies, being governmental agencies (n=4), third party certification bodies (n=3), sector associations (n=3), universities (n=1) and industry (big companies: n=6, small companies: n=3) from Belgium and the Netherlands, were asked to evaluate the relevance (does the indicator add to the understanding of food safety climate?) and the validity (does the indicator measure an important aspect of food safety climate?) of each indicator of our initial food safety climate assessment tool inspired by the method used by Kirezieva, Nanyunja, et al. (2013), which was based on de Vaus (2001) and Churchill and Iacobucci (2010). Experts from industry have been chosen based on their experience in managing food safety management systems and dealing with (non-) compliance with food hygiene measures of employees. For the governmental agencies and the third party certification bodies, the selection was based on the experience with auditing or inspection of food safety management systems in all kinds of companies and the knowledge about food safety issues in companies. The selection of the experts from sector associations was done according to experience with the development of sector guides in Belgium related to development of food safety management systems. The expert from the university was selected based on his/her experience in constructing self-assessment tools for the evaluation of food safety management system performance in the food industry.

The preliminary version of our food safety climate tool with 27 indicators was sent by e-mail to the selected experts. First, each expert had to rate whether they considered the indicator and underlying assumption relevant (Yes/No). Next, they had to evaluate the importance of the indicator for the assessment of the food safety climate by means of a four-point Likert scale (not important, somewhat important, important and very important; 0 → 3). Also, suggestions could be given by the experts. The processing of the validation results was executed according to the method used by Kirezieva, Nanyunja, et al. (2013). If 50% or less of the responding experts (n = 20) did not consider the indicator relevant, the indicator was deleted. For the importance rating, the median and interquartile range were calculated and based on the open suggestions, indicators could be made more intelligible and new indicators could be added. All twenty experts responded to the validation study (response rate: 100%). Results of the relevance evaluation and the importance scores are given in Table 2.6.

All indicators were deemed relevant for the assessment of the food safety climate by more than half of the experts (n=10). As such, none of the 27 indicators were considered for deletion. It should be noted that the cut-off value of 50% used by Kirezieva, Nanyunja, et al. (2013) could be debated. However, as in this case 95%-100% of the experts considered each indicator relevant, this does not seem to be an issue. Furthermore, the importance rating was above 2 for the majority of the indicators (scale 0 → 3; not important to very important) (Kirezieva, Nanyunja, et al., 2013). Indicator E4 was found very important to almost all of the experts. Several experts commented that leaders should be well aware of the fact that they set an example for the employees. A median score of 3 (very important) was also calculated for indicators L2, C1, C5, E5, M5, M6, R1 and R4. Expectations should be clear and should be communicated regularly. The experts also indicated the importance of open communication in the organization, as they think that employees should be able to discuss problems concerning hygiene and food safety. Commitment of the leaders can be demonstrated by setting a good example and by acting quickly when problems concerning hygiene and food safety occur. For component resources the experts indicated that education and training and good procedures and instructions should be present in the organization. Also, risks should be known and leaders should have a realistic picture of these risks.

Table 2.6: Expert validation results based on relevance and importance rating of the indicators in the food safety climate self-assessment tool

Indicator	Relevance[a]	Importance rating (0→3, not to very important)[b]
Leadership		
L1	20 (20)	2.5 (1)
L2	20 (20)	3 (1)
L3	20 (20)	2 (1)
L4	20 (20)	2 (1)
L5	19 (19)	2.5 (1)
L6	[c]	[c]
Communication		
C1	20 (20)	3 (1)
C2	19 (20)	2 (1)
C3	19 (20)	2 (1)
C4	19 (20)	2 (1)
C5	20 (20)	3 (1)
Commitment		
E1	20 (20)	2.5 (1)
E2	19 (19)	2 (1)
E3	19 (19)	2 (0)
E4	20 (20)	3 (0)
E5	20 (20)	3 (1)
E6	19 (19)	2 (0.75)

Indicator	Relevance[a]	Importance rating (0→3, not to very important)[b]
Resources		
M1	19 (20)	2 (1)
M2	20 (20)	2 (1)
M3	20 (20)	2 (1)
M4	20 (20)	2 (1)
M5	19 (20)	3 (1)
M6	19 (20)	3 (1)
Risk awareness		
R1	20 (20)	3 (0.75)
R2	16 (19)	2 (1)
R3	19 (20)	2 (2)
R4	18 (19)	3 (1)
R5	20 (20)	2 (1)

[a] number of experts considering the indicator relevant (total number of respondents for the indicator)

[b] median of the importance rating (interquartile range)

[c] indicator added after expert validation

Based on the suggestions of the experts, some minor textual adjustments were made to improve the intelligibility of some indicators and indicator L6 (‘*striving for continuous improvement*’) was added. Indeed leaders’ striving for continuous improvement regarding hygiene and food safety might denote strong leaders’ ambition and reflect the importance of hygiene and food safety in the organization and was lacking in the preliminary version of our tool. The final version of the proposed food safety climate assessment tool is shown in Tables 2.1-2.5.

2.4 Pilot study: testing in practice

In order to assess the understandability of the tool and its applicability in practice, a single pilot study was performed in eight affiliates of a large scale centrally coordinated meat distribution company (>250 employees (EC., 2003)). The company has a well elaborated FSMS in place which is certified against Belgian and European legal hygiene and food safety standards. An annual food safety and hygiene training is provided for all employees and detailed food safety/hygiene procedures and instructions are available. It can be stated that their so-called 'techno-managerial' route (see Figure 1.3) is well under control.

All employees in the eight affiliates (n = 42) and their management (including general director, quality manager, three sales managers and overall responsible of the affiliates, n=6) were invited to fill out our food safety climate self-assessment survey in order to determine and compare how the food safety climate is perceived in the different affiliates and to identify potential differences in perception between the management and the employees working in the delocated shops. The employees were not informed in advance about the subject of the survey and had to fill out the survey independently and anonymously. Filling out the survey took approximately five minutes. The mean response (1→ 5) over all 28 food safety climate indicators for each butcher shop was calculated over all employees of that butcher shop and the mean response (1→ 5) over all indicators belonging to one component was calculated for the management, each affiliate and all staff over all affiliates. Important to note here is that calculation of the mean does not imply that a normal distribution is assumed, but this is more to have an average measure to be able to compare perceptions. Moreover, it is a measure which is easy to calculate and interpret by food business operators who would use this tool to investigate their food safety climate, as the aim of this pilot study was to demonstrate the practical application and usefulness of the tool for food business operators. Statistical analysis was performed on total food safety climate scores (sum per respondent of Likert scores (1→ 5) for all 28 indicators) and total component scores (sum per respondent of Likert scores (1→ 5) for indicators belonging to a specific food safety climate component).

Although the small sample size in this pilot study does not allow to formulate strong statements or full interpretations, statistical exploration (with IBM SPSS version 22 (Chicago, Illinois)) of the data showed two remarkable findings.

Firstly, no statistical differences between the eight affiliates were found nor for their total food safety climate score nor for their total component scores (Kruskal-Wallis: $p > 0.05$). This finding might be attributed to the typical high extent of standardization and formalization of the food safety policy and management systems in large scale meat companies as measured by the techno-managerial route in a European study by Luning et al. (2015) or a Belgian study by Jacxsens et al. (2015). The lack of meaningful differences between the affiliates regarding their food safety climate might reflect the global thinking and intensive steering by the central management of this large scale meat company at hand which hinders or does not allow meaningful differences between local affiliates on key components of food safety. This explanation is in line with knowledge on organizational structure or configuration and strategic management in which outcomes of managerial centralization (Mintzberg, 1979) on the one hand and the distinction between centralized versus decentralized management systems regarding related issues such as sewage sludge and food waste (Righi, Oliviero, Pedrini, Buscaroli, & Della Casa, 2013) are well described.

Secondly, no significant difference between the total food safety climate scores of the management (mean score 4.18) and the total food safety climate scores of the employees of the eight affiliates (mean score 4.20) could be found, which means that both the management and their employees perceived a similar very good overall food safety climate within their organization (maximum score is 5 (Likert score 1→5)). Also for total component scores no significant differences could be identified (Mann-Whitney U : $p > 0.05$).

At first sight, this trend towards agreement in food safety climate perception between management and affiliates' staff suggests that both management and employees are on the same wavelength. On the other hand, this second result, which is based on the statistical comparison of total (component) scores derived from small sized subsamples, might mask particular differences. Therefore mean responses of the management and of the employees in the affiliates were calculated for each indicator separately and these mean responses are presented in Figure 2.1 in webdiagrams as this is an easy and clear representation method to be used in practice by food business operators.

Indeed, from Figure 2.1 it can be noticed that the management perceived some indicators differently than their affiliates' staff. Specifically, the affiliates' staff are more convinced that their leaders set clear objectives (L1) and can motivate their employees (L3), whereas the management scored both indicators somewhat lower. However, indicator L5 'In my organization, hygiene and food safety issues are addressed in a constructive and respectful way by the leaders.' is slightly better perceived by the management compared to the employees in the affiliates (see Figure 2.1).

For component communication, the largest difference can be seen for indicator C4. The affiliates are more convinced that food safety and hygiene is permanently present in the organization (for example by signs) than the management. No meaningful perceptual differences between management and employees are noticed for the other indicators of communication.

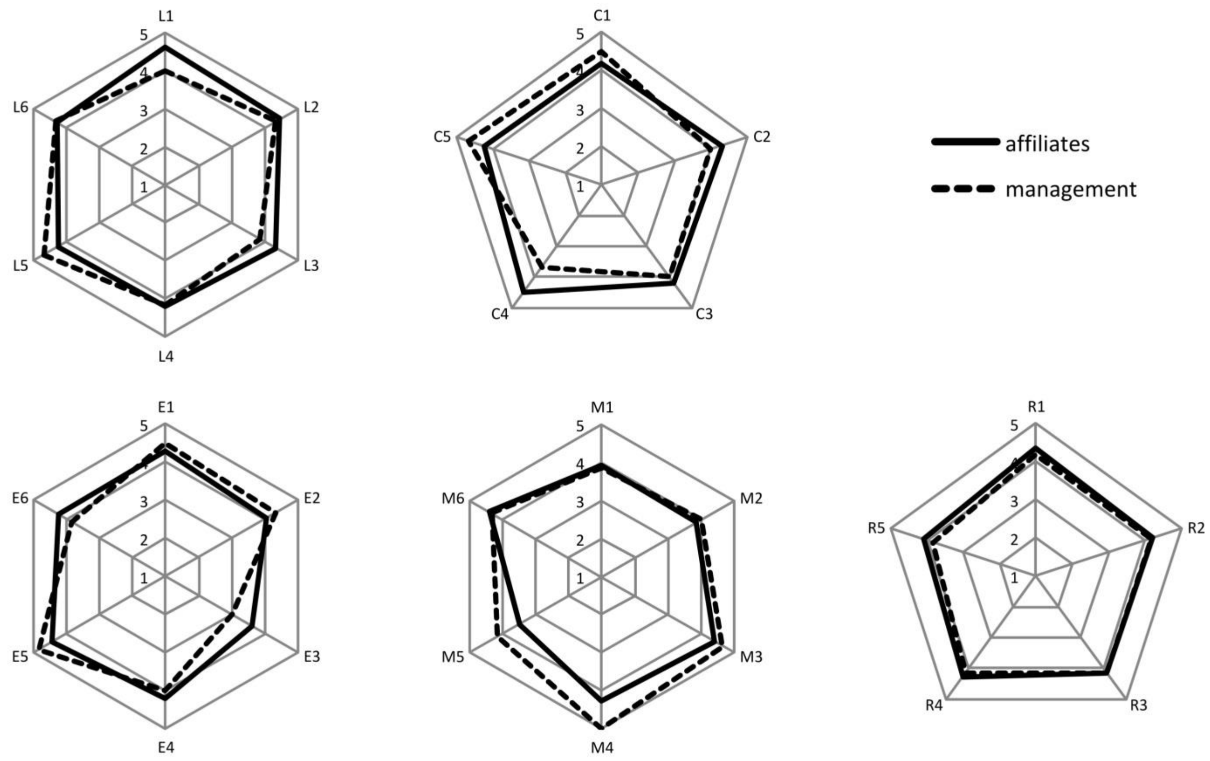

Figure 2.1: Web diagrams with the mean responses (Likert answer scale 1→ 5, totally disagree → totally agree) of the management (n=6) and the employees of affiliates (n=42) for the different indicators of the food safety climate self-assessment tool. L1-L6 for component leadership, C1-C5 for component communication, E1-E6 for component commitment, M1-M6 for component resources and R1-R5 for component risk awareness.

The higher perception on indicators E3 and E6 of the employees shows that the affiliates' staff feel actively involved and sufficiently recognized and rewarded for hygiene and food safety related matters, whereas the management thinks they could do better here. In contrast, the management gave unanimously a score of 5 for indicator M4 'sufficient financial resources', and also indicator M5 'sufficient education and training' was scored higher by the management than by the affiliates. For component risk awareness, scores by the affiliates and by the management were quite similar.

It should be noted that also other measures could have been presented instead of the mean, such as the median or the mode of the responses. As an example, web diagrams from Figure 2.1 are adjusted using the median in Appendix 2.A. Results are similar for most indicators, except for some differences in indicators L3, C5, M5 and E6. Furthermore, the median over all indicators was 4 for both affiliates and the management, which is similar to the mean values calculated for both management and affiliates (4.18 and 4.20, respectively). Still, it is important not to rely on average measures without studying the original data.

After the self-assessment, the results were communicated to the management of the large scale meat distribution company and feedback was acquired related to the tool. In line with the validation by experts, this pilot study suggests that, the presented food safety climate self-assessment survey is clear, understandable and meaningful. However, the outcomes of the pilot study should be further verified in practice with a larger group of respondents, as only a single small scale pilot study was executed. Also, it should be taken into account that the food safety climate self-assessment tool measures perceptions and gives no objective measurement.

For the affiliates' staff it was needed to clearly define who their 'leaders' are (or 'should be') in the hierarchy of their organization in order to be able to answer the questions properly. Therefore, we recommend to adapt the tool instructions accordingly in future application of the self-assessment tool. The management of the company considered the inclusion of the human dimension into their food safety management as very challenging and refreshing.

2.5 Conclusions

Food safety climate was defined as employees' (shared) perception of leadership, communication, commitment, resources and risk awareness concerning food safety and hygiene within their current work organization. Based on literature study and discussion with experts, a food safety climate self-assessment tool with 28 indicators and a Likert answer scale was developed and expert-validated. With the help of our food safety climate self-assessment tool, food companies are able to go beyond traditional food safety management and mirror the human dimension in food safety. This was illustrated in the pilot study in affiliated butcher shops with a central management and food safety management system. No significant difference was noticed between food safety climate perceptions of the centralized management and the employees of the delocated affiliates. Also within the affiliates, no statistical differences could be found. The self-assessment of the food safety climate led to interesting and challenging insights in the human dimension of their organization. However, these results should be considered with caution, as this was only a single small scale pilot study, performed to demonstrate how the tool could be used by food business operators to assess how employees perceive the food safety climate in the company. To consolidate the statements made in this paper, further research in food safety culture will link results of the food safety climate self-assessment tool to objective measurements of the company's food safety performance. Also, a larger sample size will strengthen statistical conclusions. Since (subjective) perceptions were assessed through this self-report scale to measure food safety climate, we cannot assure that all respondents rate each indicator in a sincere and conscientious way. To overcome this possible research limitation, further psychometrical validation studies are needed to demonstrate to what extent self-ratings (e.g. by an individual employee) versus other-ratings (e.g. by auditors, inspectors, colleagues) of food safety climate corroborate or are shared within a work unit/organization.

Chapter 3

Interplay between food safety climate, food safety management system and microbiological hygiene and food safety in farm butcheries and affiliated butcher shops

Redrafted from:

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Abstract

As part of the exploration of food safety climate and culture at an organizational level, in this chapter the impact of company size and structure was investigated. More specific, an in-depth case study was performed in which the food safety culture, as proposed in our conceptual model, of independent micro scale farm butcheries, exemplifying a short food chain, and affiliated butcher shops, affiliates of one large scale centrally coordinated meat distribution company, representing the conventional food chain, was assessed and compared. Four independent farm based and four affiliated centrally managed butcheries were screened on their food safety climate and level of implemented FSMS, by application of questionnaires. Additionally, objective data on the level of hygiene and food safety of products and environment were collected by product and environmental microbiological sampling. The food safety climate was scored significantly higher in the centrally managed butcher shops compared to the independent small scale farm butcheries, mainly for the components leadership and communication. The study demonstrated that the high (perceived) level of the food safety climate by the affiliated butcher shop employees, was confirmed by their higher level of microbiological hygiene and safety, assuming that an interplay might exist between their food safety climate and their well-elaborated FSMS and that both might support and interact with each other. In the investigated farm butcheries, the lower level of microbiological hygiene and food safety might be linked to the more basic FSMS. The fact that food safety climate was still perceived to be on a high level, might expose a potential hazard of optimistic bias and complacency among the farm butchery employees.

3.1 Introduction

Europe houses a wide range of food companies (Dora et al., 2013). On the one hand, globalization results in formation of multinationals, on the other hand more than 90% of the European food companies are small and medium enterprises (SME's) (FoodDrinkEurope, 2014). In certain sectors also micro scale companies are numerous (e.g. traditional dry sausage producers in Northern Italy (Conter et al., 2007) and (raw milk) cheese producers in Greece and Italy (Campolo, Romeo, Attina, Zappala, & Palmeri, 2013; Panagou, Nychas, & Sofos, 2013)). An increasing trend in short food chains is occurring with typical examples such as dairy or meat farms hosting also processing and selling activities to the (local) consumers. Health and sustainability concerns motivate consumers to look for high quality foods, meaning fresh, tasteful, nutritionally qualitative and safe food, and sales direct from the source. The face to face or proximate contact between the grower/producer and the consumer is a typical characteristic of these short food chains (Uyttendaele, Herman, Daeseleire, Huyghebaert, & Pussemier, 2012). The fact that the persons in charge are engaged in multiple simultaneous assignments and the lack of profound knowledge or technically qualified personnel in the short food chain to assess the risks associated with their products may put a challenge to manage food safety (Conter et al., 2007; Uyttendaele et al., 2012).

However, as discussed in section 1.1.2, certain flexibilities are possible for smaller food companies in order to ease the burden of administration and implementation of rules for these companies, such as for example the recent EFSA opinion, proposing a simplified approach for hazard analysis for specific types of independent small retail establishments (e.g. butcher shops) (CAC, 2003; EC., 2002; EFSA_BIOHAZ, 2017). But the question here remains whether this flexibility and lack of knowledge and technically qualified personnel may pose a greater risk for foodborne disease, especially when working with, for example, raw meat (in case of butcher shops) which is a quite risky product from microbiological perspective. For example, the William Tudor and John Barr, both proprietors of butcher shops, *E.coli* O157 outbreaks in UK, illustrate the potential consequences of small butcher shops operating unsafely for years (Pennington, 2014). In both cases contaminated meat and meat products resulted in a large number of infected people (503 and 157 in Barr and Tudor outbreak respectively), and even killed some people (17 and 1 in in Barr and Tudor outbreak respectively). Public inquiries determined in both cases that microbiological hazards were ignored and appropriate measures to control these hazards were lacking. Moreover, both John Barr and William Tudor deceived food inspectors, which suggests that they prioritized production and profit over hygiene and food safety, which has led to severe consequences (Nayak & Waterson, 2016). Powell et al. (2011) suggest that the negative food safety culture in the Tudor butcher shop has to a large extent contributed to the outbreak.

Still, the implementation of a FSMS is more challenging for small and medium sized food enterprises mainly due to a lack of resources, competencies and economical disadvantages because of their small scale and limited power towards suppliers (Antony et al., 2008; Dora et al., 2013; Walker et al., 2003). For example, Walker et al. (2003) mention lack of time and expertise as a barrier for adequate implementation of Hazard Analysis Critical Control Points (HACCP). Lack of knowledge and expertise was also identified by Conter et al. (2007) in the traditional dry sausage manufacture in Northern Italy. In a study in small salami and soppresse production facilities in the Veneto Region, Italy, Roccato et al. (2017) saw that food business operators largely relied on traditional know-how and that fermentation processes were characterized by a low level of standardization, because of varying environmental conditions such as temperature and humidity. Still, because of the restricted number of processing and transaction steps and the lower number of employees in these small traditional butcher shops, efficient communication and control might be facilitated (Roccato et al., 2017).

A cross-European study of Luning et al. (2015) demonstrated that some small and medium enterprises manage to have an advanced FSMS, and achieve an appropriate safety level of their produced products. However, their typical organizational characteristics such as less resources (educated staff, laboratory facilities, time), more restricted formalization (restricted use of procedures and formal meetings), limited information systems, but more stable workforce, might require more tailored support from government and/or sector associations to develop towards advanced systems in the case of high-risk products and processes such as meat, fish and dairy production. This was also concluded by Oses et al. (2012a) in their study in the lamb chain. The small butcher shops lacked specific food safety expertise and formalization and information systems were restricted. However, also in these butcher shops the variability of the workforce was low and a high degree of employee involvement was reported. Some authors presume that in smaller companies, more commitment is present from the management (often the owners of the company or family businesses) and the small group of employees, because they are more concerned on values as taste, nutrition, quality and safety (Berlin, Lockeretz, & Bell, 2009; Herman, Heyndrickx, De Reu, Van Coillie, & Uyttendaele, 2012; van der Merwe, Venter, & Farrington, 2012). Also, personal contact with the customer can motivate employees towards a larger responsibility and commitment (Herman et al., 2012). These aspects reflect the human dimension of food safety management which is expected to be expressed in the company's food safety culture.

Indeed, in this chapter the potential impact of company size and structure on an organization's food safety culture will be investigated by an in depth case study. More specifically, focus will be on the potential difference in food safety culture, as defined in our conceptual model (Figure 1.3), between independent micro scale farm butcheries, exemplifying a short food chain, and affiliated butcher shops, all being affiliates of one large scale centrally coordinated (corporate-managed) meat distribution company, representing the conventional food chain. As such, the different aspects of food safety culture , as represented in the food safety culture conceptual model (Figure 1.3) and explained in section 1.4.2 will be assessed. Therefore, in parallel to questionnaires assessing the food safety climate and performance of the FSMS (and its context), also samples were taken of both minced beef meat and the production environment and analyzed for selected pathogens and hygiene indicators to obtain information on the actual level of food safety and hygiene in the companies included in the case study. As such the food safety culture of both types of butcheries, representing organizations with different organizational characteristics and a different type of organizational structure (small independent short-chain shops versus corporate-managed conventional-chain shops), could be evaluated and compared. This in-depth work is considered as an exploratory qualitative case study.

3.2 Material and methods

3.2.1 Assessment of company characteristics and production process

Four independent micro scale farm butcheries (<10 employees (EC., 2003)), which can be considered short-chain as they keep their own cattle and sell directly to the (local) consumer, were selected based on information on their websites and willingness to cooperate (n=4, indicated as FB1-4). FB1 consists of one owner/butcher and one shopkeeper, FB2 of two owners, a butcher and a shopkeeper, FB3 of three owners and seven butchers/shopkeepers and FB4 of one owner and three butchers/shopkeepers. The four participating affiliated butcher shops, all being affiliates of a large scale corporate-managed meat distribution company can be considered conventional chain butcher shops (indicated as AB). The large scale meat distribution company employs > 1000 employees, spread over different affiliates in Belgium, with in each affiliate five to ten employees. Cooperation to this research was upon voluntary basis and the involved butcheries are therefore not representing the whole meat distribution sector in Belgium. The short chain farm butcheries implemented legal required good practices and a self-checking system for small scale butcheries, receive inspections from the Belgian food safety authority but did not have a formal certified FSMS. Whilst the affiliated butcher shops have HACCP in place and a certified self-checking system for conventional butcheries required in Belgium (EC., 2004b; RD., 2003). In addition, the large scale meat distribution company has a central quality department (four persons) with a quality manager to support its affiliates. The method for the preparation of the raw minced beef meat is quite similar in all investigated short chain butcheries. Meat from carcasses or parts of carcasses of own bred cows, after being slaughtered in a slaughterhouse, are minced and stored in trays in a cooling unit. Only FB3 sells the products vacuum packed and frozen. The affiliated butcher shops start with carcasses and prepackaged meat parts which are centrally purchased from suppliers and delivered on a daily basis to the affiliates. No other ingredients are added to the raw minced beef meat. Also, the minced beef meat was stored no longer than 24 hours in refrigerated conditions neither in the farm butcheries nor in the affiliated butcher shops.

3.2.2 Assessment of context, food safety management system activities and system output

For the assessment of the context of the company, the current level of the implemented FSMS and the system output the FSMS-diagnostic instrument (FSMS-DI) for animal food production was used (Luning, Marcelis, et al., 2011a). This assessment tool consists of four parts with in total 58 indicators with grids including descriptions of different situations (see Appendix 3.A for an overview of FSMS-DI indicators).

Part I assesses the risk level of the context wherein the FSMS operates, with questions on product and process characteristics, chain environment of the company and organizational characteristics. Part II evaluates the levels of core control activities implemented to prevent that microbiological contamination can occur or growth is possible (Luning et al., 2008). Part III includes the evaluation of core assurance activities of the FSMS to demonstrate whether the FSMS is working effectively (Luning et al., 2009). Finally, part IV contains system output questions, which is actually a type of FSMS performance assessment to assess whether and how the organization evaluates its own FSMS and gains insight in the performance of its FSMS, by e.g. registration and follow-up of customer complaints and results of microbiological sampling (Jacxsens et al., 2010).

By means of three different situations the respondent has to choose whether the company or product is in a low (score 1), moderate (score 2) or high-risk (score 3) situation with regard to the context (Luning, Marcelis, et al., 2011a), and whether the control and assurance activities can be considered absent (score 0), basic, based on historical knowledge (score 1), average, based on sector information (score 2) or advanced or fit-for-purpose, based on company specific and validated information (score 3) (Luning et al., 2008). Also, a first insight can be gained in the system output of the FSMS by attributing a poor (score 0), moderate (score 1) or good (score 2) score on nine indicators (Jacxsens et al., 2010). An example of one of the indicators to assess an organization's control activities is given in Appendix 3.B. This FSMS-diagnostic instrument systematically assesses the effectiveness of the FSMS and was already validated in several studies in various food sectors (e.g. in Belgian food processing companies to compare performance between certified and non-certified FSMS systems (Jacxsens et al., 2015), in animal based food companies (Luning et al., 2015), in the lamb chain (Oses et al., 2012b) and in Japanese milk processing plants (Sampers, Toyofuku, Luning, Uyttendaele, & Jacxsens, 2012)).

Based on an in-depth interview with the quality manager of the four affiliated butcher shops AB1-AB4 and with the four owners of the short chain farm butcheries FB1-FB4, the 58 indicators of the FSMS assessment tool were evaluated. Data were analyzed using the method proposed by Luning, Jacxsens, et al. (2011). In order to obtain an overall indication of the level of context riskiness (product/process related contextual factors and organizational/chain related contextual factors separately), control activities, assurance activities and of the system output, the authors recommend to calculate the mean value of the indicators belonging to each of these parts of the FSMS-DI. As mean scores with decimals would not have any meaning (because scores represent qualitative descriptions), these mean scores are transformed to assigned scores, representing the range wherein the mean scores fall. These assigned scores are then linked to an interpretation, as illustrated in Luning, Jacxsens, et al. (2011). If the mean score of the indicators for control activities, assurance activities and system output was between 0 and 0.2 the assigned score was 0, for a mean of 0.3 to 1.2 the assigned score was 1, for a mean of 1.3 to 1.7 the assigned score was 1_2, for a mean of 1.8 to 2.2 the assigned score was 2, for a mean of 2.3 to 2.7 the assigned score was 2_3, and for a mean of 2.8 to 3.0 the assigned score was 3. Similarly, for a mean score for the context riskiness of 1 to 1.2 the assigned situation score was 1, for a mean score of 1.3 to 1.7 the assigned score was 1_2, for a mean score of 1.8 to 2.2 the assigned score was 2, for a mean score of 2.3 to 2.7 the assigned score was 2_3, and for a mean score of 2.8 to 3.0 the assigned score was 3.

3.2.3 Assessment of the food safety climate

For the assessment of the food safety climate, perceptions of all employees in the farm butcheries and the affiliated butcher shops were assessed, using the food safety climate self-assessment tool as described in chapter 2. The twenty eight indicators allow to assess perceptions of five key components of food safety climate, being leadership (6 indictors), communication (5 indicators), commitment (6 indicators), resources (6 indicators) and risk awareness (5 indicators). Each indicator was scored by means of a five-point Likert answer scale (1→ 5: totally disagree, disagree, neutral, agree, totally agree) (see Appendix 3.C for complete survey used in the butcheries). The indicators and answer scale were constructed in a way that a higher score on the answer scale (higher agreement with statements) corresponds with a better perceived food safety climate in the company. This survey was conducted among the owners and every employee of the four short chain farm butcheries (FB1-FB4) (n=16). In the four affiliated butcher shops (AB1-AB4) all employees in the affiliates, were questioned (n=23). The employees had to fill out the survey independently and anonymously during their break. It took approximately five minutes to fill out the survey. The total sample size for both the farm butcheries and the affiliated butcher shops was 39 respondents. For statistical analysis total food safety climate scores (sum of Likert scores (1→5) of 28 indicators) and component scores (sum of Likert scores (1→5) for each component separately) were calculated. Statistical analysis was performed with IBM SPSS Statistics 22 (Chicago, Illinois).

3.2.4 Assessment of the food safety output: the level of food safety and hygiene of food products and production environment

Samples from the production environment and raw minced beef meat were taken during three visits to each of the farm butcheries and to each of the affiliated butcher shops (Table 3.1). All visits were executed in the morning with random intervals within three months. The affiliated butcher shops were not aware of the date and time of sampling. Because of organizational reasons, the short chain farm butcheries did know when the sampling would be done. During each visit, five environmental swabs (3M™ Sponge-Stick with Buffered Peptone Water Broth, SSL10BPW) were taken to assess the presence of *Listeria monocytogenes* (in each company: wheels of trolley in the production environment, rubber of fridge door, drain grate, contact surface in use, contact surface not in use). The used swabbing method has been proven to be appropriate for the detection of *L. monocytogenes* in food processing environments (Lahou & Uyttendaele, 2014). Also, the hands from all staff present at the time of the visit were swabbed with a premoistened sterile rayon swab in 5 ml of sterile peptone water. It was registered whether gloves were worn and which task the person was executing. Gloves were obligatory for the preparation of minced meat. In total, 69 hands were swabbed. In addition to the environmental swabs and hand swabs, two ready-to-sell raw minced beef meat samples were taken from the counter and, if possible, two raw minced beef meat samples from the fridge, except for FB3, as the raw minced beef meat is sold frozen. For the raw minced beef meat 300 g was aseptically collected with a sterile spoon and transferred to a sterile plastic bag. Temperature of the product (Sunartis® digital thermometer) and the time since preparation was registered.

All the samples and swabs were transported in a cool box at 4°C to the laboratory. Microbiological analyses were performed in the laboratory within 6 h of sample collection. For enumeration of the raw minced beef meat samples, 10 g of the sample was homogenized for 1 min in 90 ml of sterile peptone water. For the detection of *Salmonella* spp. and *L. monocytogenes*, a subsample of 25 g was taken and homogenized for 1 min in 225 ml of buffered peptone water for the detection of *Salmonella* spp. and demi-Fraser for the detection of *L. monocytogenes.* The premoistened environmental swabs for detection of *L. monocytogenes* were homogenized in 100 ml of demi-Fraser. For microbial enumeration tenfold serial dilutions were made in sterile peptone water. For the handswabs tenfold dilutions could be made directly from the rayon swab tube after vortexing for

10 seconds. Table 3.1 shows the micro-organisms which were analyzed and the applied methods. For the statistical analysis of the microbiological results IBM SPSS Statistics 22 (Chicago, Illinois) was used. Because of the limitation in the number of samples taken, non-parametric tests were performed, i.e. Kruskal-Wallis and Mann-Whitney U tests.

Table 3.1: Overview of microbiological analysis (sample type and analytical method) applied for meat samples, environmental samples and hands of workers.

Parameter	Method	Sample (sample area or sample weight)
Listeria monocytogenes	Enrichment: Demi Fraser 24 ± 2h, 30°C (bioMérieux 42727) Fraser 24 ± 2h, 37°C (bioMérieux 42072) Detection: Vidas Immunoassay LMO2 kit (bioMérieux 30704) AFNOR validated enzyme-linked fluorescent assay (ELFA) (BIO 12/11-03/04) Confirmation and enumeration: ALOA (Oxoid CM1084) ISO 11290-2:1998/Amd 1:2004	-*Listeria* swabs (100 cm²) -Raw minced beef (25 g) -Raw minced beef (10 g) (enumeration)
***Salmonella* spp.**	Enrichment: Buffered Pepton Water (10 ± 2h, 41.5°C) (Oxoid CM0509) Detection: GeneDisc Protocol (Raw Beef Meat) (Pall, GSTECSL206006)	-Raw minced beef (25 g)
***E.coli* O157:H7**	Enrichment: Buffered Pepton Water (10 ± 2h, 41.5°C) (Oxoid CM0509) Detection: GeneDisc Protocol (Raw Beef Meat) (Pall, GSTECSL206006)	-Raw minced beef (25 g)
E. coli	Count by Plating: RAPID'*E.coli* 2 Medium (Bio-Rad 356-4024) Incubation: 24 ± 2h, 37°C	-Hand swabs (50 cm²) -Raw minced beef (10 g)
Enterobacteria-ceae	Count by Plating: VRBG with overlayer (Oxoid CM0485) Incubation: 24 ± 2h, 37°C ISO 21528-2:2004	-Raw minced beef (10 g)
Staphylococcus aureus	Count by Plating: Baird Parker (Oxoid CM0275+SR0054) Incubation: 48 ± 2h, 37°C ISO 6888-1:1999/Amd 1:2003	-Raw minced beef (10 g)
Total viable count	Count by Plating: Plate Count Agar (Oxoid CM0325) Incubation: 72 ± 2h, 30°C (22°C for meat) (Modified) ISO 4833:2003	-Hand swabs (50 cm²) -Raw minced beef (10 g)
Lactic acid bacteria	Count by Plating: Man Rogosa Sharpe with overlayer (Oxoid CM0361) Incubation: 120 ± 2h, 22°C Modified ISO 15214:1998	-Raw minced beef (10 g)

3.2.5 Microbiological criteria or guidelines to evaluate meat and environmental samples

The results of the raw minced beef meat were compared with microbiological criteria to come to a ranking of the different butcheries. Table 3.2 shows the legal criteria for the different parameters (EC., 2005). If no legal criteria are present, microbiological guidelines established by the Research unit of Food Microbiology and Food Preservation (FMFP) of Ghent University are given (Uyttendaele, Jacxsens, De Loy-Hendrickx, Devlieghere, & Debevere, 2010). As EU Regulation 2073/2005 (EC., 2005) only sets criteria for the total mesophilic count and psychrotrophic count was determined in the case study, the microbiological guidelines of FMFP were used for total psychrotrophic count. Legislative criteria for *E. coli* are process hygiene criteria for minced meat (EC., 2005).

Table 3.2: Legal requirements or microbiological guidelines for different parameters of the minced beef meat.

Legal requirements / microbial guidelines (cfu/g)		
Parameter	Objective (m)	Tolerance/Threshold (M)
Total aerobic psychrotrophic count[2]	10^5	10^6
E. coli[1]	5 x 10	5 x 10^2
S. aureus[2]	10^2	10^3
Salmonella spp.[3]	Absence in 25 g	
Listeria monocytogenes[3]	Absence in 25 g	
E. coli O157:H7[2]	Absence in 25 g	

m: maximum level of microorganisms per test volume considered acceptable (food with values above this level in any sample is either marginally acceptable or unacceptable)
M: maximum level of microorganisms per test volume considered marginally acceptable (food with values at or above M in any sample is unacceptable)
[1] Legal requirements according to EU Regulation 2073/2005
[2] Microbial guideline for minced raw meat (whether or not intended to be eaten raw) based on beef, pork or poultry according to microbiological guidelines of the FMFP-UGent (Uyttendaele et al., 2010)
[3] Legal requirements according to EU Regulation 2073/2005 in category minced meat and meat preparations intended to be eaten raw (*Salmonella* spp.) or ready-to-eat foods able to support growth of *L. monocytogenes* (*L. monocytogenes,* no shelf-life tests performed), as minced meat and meat preparations are sometimes consumed raw in Belgium (e.g. steak tartare).

Important to mention here is that in Belgium minced beef meat is also consumed raw as 'steak tartare' or 'américain'. Because of this, included legislative criteria for *Salmonella* spp. are for minced meat and meat preparations intended to be eaten raw (Table 3.2). Also for *L. monocytogenes* the criteria for ready-to-eat foods able to support growth of *L. monocytogenes* were used, because of the potential consumption without cooking. The criteria for *L. monocytogenes* 'absence in 25 g' applies to products, which did not leave yet the immediate control of the food business operator, when the food business operator is not able to demonstrate that the product will not exceed 100 cfu/g throughout the shelf-life. As no such tests were performed in this research, the criteria of 'absence in

25 g’ was utilized. The maximally allowed temperature for minced meat is 2°C according to EU Regulation 853/2004 (EC., 2004c).

3.2.6 Food safety culture

The affiliated butcher shops and short chain farm butcheries were ranked relative to each other for all of the evaluated parameters being perception of food safety climate, performance of FSMS and their level of food safety and hygiene based on meat samples, environmental samples and hand swabs. This allows to get insight in different aspects of the company’s food safety culture according to our food safety culture conceptual model (Figure 1.3). For food safety climate, the ranking was based on statistical differences between the food safety climate scores of the different butcheries. For the context characteristics, the FSMS and the system output the ranking was based on the assigned scores. To obtain a visual representation (and a ranking) of the level of hygiene and food safety in each of the butcher shops, the percentage of conformity of each of the butcher shops was calculated for the meat samples, the environmental swabs and the hand swabs separately. For the meat samples this was calculated as: 100% - ‘percentage of exceedance of criteria/guidelines (section 3.2.5)’, for the environmental swabs this is the fraction of samples in which *L. monocytogenes* was detected and for the hand swabs, the fraction of samples in which *E. coli* was detected, as *E.coli* is considered as a valid indicator of fecal origin, for which presence can be linked to possible presence of fecal pathogens (Uyttendaele et al., 2018; Uyttendaele et al., 2010). As such, all three variables were taken into account: microbiological results of the meat, environmental swabs and hand swabs. The reason for this is that microbiological results of the raw beef meat may only be a reflection of the initial quality/safety of the incoming meat, whereas the environmental swabs and hand swabs can really reflect the working practices in the butchery. So both aspects were included.

3.3 Results and discussion

3.3.1 Food safety climate

The mode of the responses (1→ 5) on the food safety climate indicators for each butchery calculated over all employees of each butchery is given in Table 3.3. No significant differences were found within the total food safety climate scores of the different farm butcheries, based on a Kruskal-Wallis test ($p > 0.05$) and Mann-Whitney U ($p > 0.008$). It has to be mentioned though, that the sample size is quite small (n=16 respondents), so it is possible that meaningful differences are not statistically detected in this case study. However, considering the modes in Table 3.3, it can be noticed that FB1 scores the food safety climate lower than the other short chain butcheries. This might be due to a low perception of the food safety climate by the employee (shopkeeper), whilst the owner scored the food safety climate quite high. However, as only two persons were active in this butchery, it could be questioned whether it is appropriate to speak of a company ‘culture’ in this case. Still, the discrepancy between the perception of leaders (owners) and employees (shopkeepers/butchers) can expose problems in cooperation and trust, and can have an effect on job performance and work attitudes (Cogliser, Schriesheim, Scandura, & Gardner, 2009; Luria, 2010). Indeed, Cogliser et al. (2009) found that a positive congruent relationship (both leader and follower give a high rating) between leader and follower perception of the leader-member exchange can be linked to higher follower job performance, organizational commitment and job satisfaction.

Table 3.3: Mode of responses (1→5) on the food safety climate indicators for each butchery calculated over all employees of each butchery with n: number of people per butchery who filled in the survey.

Butchery	Mode (1→5)	n
FB1	3	2
FB2	4	4
FB3	4	6
FB4	4	4
AB1	4	7
AB2	4	6
AB3	5	4
AB4	5	6

Another remark which can be made here is that it is more difficult to organize hygiene and food safety training for only two people. This can have an effect on the perception of the importance of hygiene and food safety and, as such, on food safety climate in the butchery, which is in this case estimated lower by the employee. Considering the perception of the food safety climate by the individual affiliated butcher shops, AB3 and AB4 perceive the food safety climate on a higher level than AB1 and AB2 (Table 3.3). But this was not significant based on Kruskal-Wallis test ($p > 0.05$) and Mann-Whitney U ($p > 0.008$). For the pooled total food safety climate scores of all affiliated butcher shops ($n = 23$) versus all independent short chain farm butcheries ($n = 16$), a significant difference could be detected between both types of fresh meat selling points ($p = 0.046$). The answers of the affiliated butcher shops are significantly higher than these of the short chain farm butcheries, which can be seen in Table 3.4.

Table 3.4 gives the detailed results of the food safety climate self-assessment survey expressed as distribution of the frequency and mode of the five-point Likert answer scale (1→ 5: totally disagree, disagree, neutral, agree, totally agree) of the farm butcheries and the affiliated butcher shops over the different food safety climate components: leadership, communication, commitment, resources and risk awareness. It can be noticed that the modes of the farm butcheries over the different indicators are mainly 4, whereas in the affiliated butcher shops modes are often equal to 5, especially for components leadership, communication and resources. Also, in total, 91.93% responses of the affiliated butcher shops were 4 ‘Agree’ or 5 ‘Totally agree’. For the farm butcheries this was 83.26%, indicating that respondents in farm butcheries more often ‘(totally) disagreed’ or ‘nor disagreed nor agreed’ with the statements. Actually the reverse of this outcome could have been expected, as it could be assumed that employees and owners of the farm butcheries are, in comparison with employees working in a large scale firm, more personally connected to their customers, feel more personally accountable for problems in the butchery, and are not ‘just executing their job’ without caring about responsibilities (Herman et al., 2012; Oses et al., 2012a). Moreover, owners/employees of the farm butcheries are often living in the neighborhood and are socially active in this neighborhood. As such, they could be more engaged and one might expect that their work behavior is more service and customer oriented. So, they are inclined to make sure their customers are satisfied and no food safety problems are occurring in the butchery by executing their work properly and hygienically. Of course, these food safety climate results are based on perceptions and should be interpreted with caution. Also, the possiblility should be taken into account that employees in the affiliated butcher shops sense more corporate pressure to respond socially desirable, which could explain the higher food safety climate scores.

Comparing the pooled food safety climate scores on component level (leadership, communication, commitment, resources and risk awareness) gives a significant difference for the food safety climate component communication ($p = 0.008$) and component leadership ($p = 0.035$) between the farm butcheries and affiliated butcher shops (Table 3.4).

Table 3.4: Results of the food safety climate self-assessment survey expressed as frequency distribution and mode (bold) of five-point Likert scale (1→ 5: totally disagree→totally agree) for the 28 indicators by the responding farm butcheries and affiliated butchers. (detailed questionnaire in appendix 3.A).

	Frequencies of farm butcheries (n=16)					Frequencies of affiliated butcher shops (n=23)				
Indicator	1	2	3	4	5	1	2	3	4	5
L1	0	0	1	**10**	5	0	0	0	6	**17**
L2	0	0	2	**9**	5	0	0	1	5	**17**
L3	0	0	4	**7**	5	0	0	0	**12**	11
L4	0	0	1	**8**	7	0	0	1	10	**12**
L5	0	0	2	**10**	4	0	0	0	**13**	10
L6	0	0	1	**9**	6	0	0	1	7	**15**
Total Leadership (%)	0[a]	0[a]	11.46[a]	**55.21[a]**	33.33[a]	0[b]	0[b]	2.17[b]	38.41[b]	**59.42[b]**
C1	0	1	3	**9**	3	0	0	2	**12**	9
C2	0	1	3	**8**	4	0	0	0	**12**	11
C3	0	0	1	**8**	7	0	0	2	9	**12**
C4	0	0	3	**11**	2	0	0	0	5	**18**
C5	0	1	1	**12**	2	0	0	0	11	**12**
Total Communica-tion (%)	0[a]	3.75[a]	13.75[a]	**60[a]**	22.5[a]	0[b]	0[b]	3.48[b]	42.61[b]	**53.91[b]**
E1	0	0	1	7	**8**	0	0	0	**13**	10
E2	0	0	2	**11**	3	0	0	2	**12**	9
E3	0	0	**7**	**7**	2	0	1	7	**12**	3
E4	0	0	2	**9**	5	0	0	2	**11**	10
E5	0	0	1	**10**	5	0	0	1	7	**15**
E6	0	0	2	**9**	5	0	0	2	8	**13**
Total Commitment (%)	0	0	15.63	**55.21**	29.17	0	0.72	10.14	**45.65**	43.48
M1	0	0	5	**8**	3	0	0	7	**8**	**8**
M2	0	1	2	**8**	5	0	0	6	8	**9**
M3	0	0	1	**9**	6	0	0	1	7	**15**
M4	0	1	2	**9**	4	0	0	1	10	**12**
M5	1	2	5	**7**	1	1	2	6	**10**	4
M6	0	0	5	**9**	2	0	0	1	10	**12**
Total Resources (%)	1.04	4.17	20.83	**52.08**	21.88	0.72	1.45	15.94	38.41	**43.48**
R1	0	0	0	**11**	5	0	0	1	10	**12**
R2	0	0	2	**10**	4	0	0	1	**11**	**11**
R3	0	0	3	6	**7**	0	0	0	**19**	4
R4	0	0	2	**9**	5	0	0	1	**12**	10
R5	0	0	3	**7**	6	0	0	2	**16**	5
Total Risk awareness (%)	0	0	12.5	**53.75**	33.75	0	0	4.35	**59.13**	36.52
Total food safety climate (%)	0.22	1.56	14.96	**55.13**	28.13	0.16	0.47	7.45	44.41	**47.52**

Statistical significant differences for the overall component scores between farm butcheries and affiliated butcher shops are indicated by different letters in superscript (a < b) (Mann-Whitney U: $p < 0.05$).

The affiliated butcher shops gave a higher score indicating that communication and leadership is better perceived in these corporate-managed butcher shops. This is a remarkable finding because in a large scale company, the management is often delocated from the individual butcher shops and food safety policy is often more centralized and formalized (Daft, 2009). Apparently, the central management is able to disseminate its food safety message effectively among the employees. However, it is also possible that the larger organizational size of the large scale firm requires more structured communication which can be managed by more trained people available in a larger firm, whereas food safety information in small scale companies or in this case the farm butcheries is more ad hoc and probably less efficient and structured (Luning et al., 2015; Oses et al., 2012a). For the other components of food safety climate no significant differences could be found ($p > 0.05$) although for resources a higher mode was calculated for the affiliated butcher shops, while components commitment and risk awareness were similar (see Table 3.4).

In order to reveal which indicator(s) is (are) responsible for the difference in perception concerning communication and leadership between the farm butcheries and the affiliated butcher shops, Mann-Whitney U tests were performed for the separate indicators (C1-C5 and L1-L6) of component communication and leadership. From this, it could be concluded that differences for component communication are situated in indicators C4 ‘the importance of hygiene and food safety is permanently present by means of, for example, posters, signs and/or icons related to hygiene and food safety’ and C5 ‘I can discuss problems concerning hygiene and food safety with colleagues’ ($p < 0.05$). Discussion with colleagues about hygiene and food safety is more possible in the affiliated butcher shops than in the farm butcheries (C5). This is a remarkable finding, as it would be expected that in the farm butcheries where a small number of people are working more closely together, people are more communicative towards each other. Maybe the typical small organizational size of the studied farm butcheries facilitates a more social-oriented than task-oriented way of communication among its members, in which food safety and hygiene issues are less dominant (Lin, Huang, Du, & Lin, 2012). Alternatively, it might be that employees’ work demands (e.g. quantitative workload, time pressure) in farm butcheries are higher and/or more psychologically threatening, implying that less time or room is available to discuss food safety and hygiene issues with colleagues and/or their leaders (Van de Ven, Vlerick, & de Jonge, 2008).

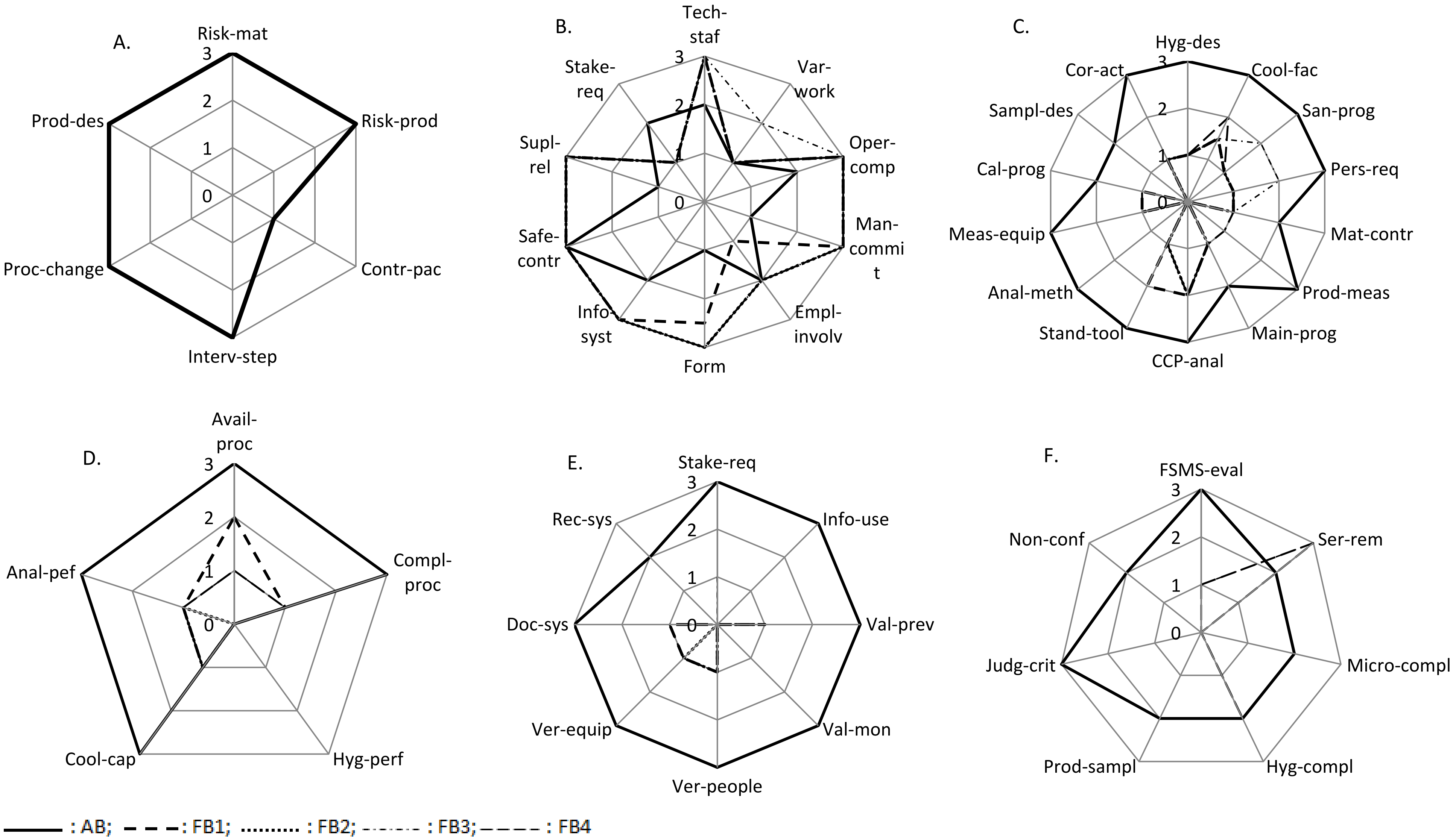
The fact that the importance of hygiene and food safety by for example, posters, signs and/or icons related to hygiene and food safety (C4) is perceived to be more present in the affiliated butcher shops can be expected, as these signs and posters are centrally developed and distributed to all affiliates. This also shows the importance of regular training of the personnel and regular repetition of the important food safety and hygiene related topics of these trainings. However, it is not obvious for a large scale firm to have good communication and to have leaders who behave and manage in a food safe manner. For example, the *L. monocytogenes* outbreak in 2008 linked to the large scale firm Maple Leaf Foods could be attributed, among others, to a food safety culture/climate which was not sufficient to manage the risks in the company. One of the problems was the fact that important food safety information did not reach the office of the Chief Executive Officer and as such, could not be handled properly (Powell et al., 2011).

For component leadership indicators L1 'Setting of clear objectives concerning food safety and hygiene' and L2 'set clear expectations towards the employees' were scored significantly higher in the affiliated butcher shops ($p < 0.05$). This means that the management of the affiliated butcher shops set clear objectives regarding hygiene and food safety and they manage to make sure that employees know what is expected from them. This could be expected as the affiliated butcher shops are coordinated by a large central organization in which trained people are available which can efficiently transmit this information to the affiliated butcher shops.

It can be concluded that the affiliated butcher shops perceive the food safety climate significantly higher than the farm butcheries. When looking at the components in the food safety climate tool, communication and leadership are significantly higher perceived in affiliated butcher shops compared to short chain farm butcheries, although their delocated structure makes it more difficult for the overarching management to communicate on a continuous basis and to deal with the day to day management of the affiliates. However, these results should be interpreted with caution as, although scores were lower for farm butcheries, based on Table 3.4 (and Table 3.3) it can be stated that both farm butcheries and affiliated butcher shops appear to perceive their food safety climate to be on a good to very good level, as modes over all indicators were always 4 or 5 (except for FB1), which means that respondents most often agreed or totally agreed with the statements. So overall, employees of both the affiliated butcher shops and the farm butcheries perceive their food safety climate to be on a good to very good level.

3.3.2 Risk level of context and performance of current food safety management system

The risk level of the context in which the fresh meat shop is operating and the performance of the current implemented FSMS was measured by means of the diagnostic tool (section 3.2.2). The short chain butcheries are independent companies, so for FB1 up to FB4 individual results are obtained, whereas for the four affiliated butcher shops, a central FSMS is worked out by the management and implemented in the different affiliates. Therefore, only one result is obtained for AB1 up to AB4 (see Figure 3.1 and Appendix 3.A).



: AB; : FB1; : FB2; : FB3; : FB4

Figure 3.1: Web diagrams of A: product/process related contextual factors; B: organizational/chain related contextual factors; C: design of control activities; D: operation of control activities; E: assurance activities; F: system output for the different butcheries. (abbreviations of key FSMS indicators: Appendix 3.A)

As all of the butcheries included in this study are working with the same type of product i.e. raw meat, the product/process related contextual factors are moderate to very risky (assigned score 2_3), indicating that there is a potential microbiological risk linked to the raw materials (being carcasses or technical parts of beef meat) and the final product under investigation in the current study i.e. minced beef meat (Mora et al., 2007; Papadopoulou et al., 2012). Due to the fact that similar raw materials and production processes are applied, no differentiation can be made between short chain farm butcheries and the affiliated butcher shops on these indicators (Figure 3.1A).

For the short chain butcheries, the organizational/chain related contextual factors, illustrated in Figure 3.1B, indicate a moderate to high risk situation (assigned score 2_3), whilst the affiliated butcher's shops have a low to moderate risk situation (assigned score 1_2) because they belong to a large scale firm with a higher degree of formalization and a stronger power towards suppliers (Luning et al., 2015). They obtained an assigned score for control activities of 2_3, indicating that their control activities are conducted between generic, sector (level 2) and more tailored, fit-for purpose level (level 3) (Figure 3.1C and 3.1D). In practice, it means that their cooling facilities, cleaning and disinfection program, maintenance program etc. are based on best practices for this sector or adapted to the company's own situation (Luning et al., 2015). For the assurance activities the affiliated butcher shops had an assigned score of 3, which means that the assurance activities are tailored to the company-own situation. The farm butcheries though, have only a basic FSMS, shown by their low level of control and assurance activities (assigned score of 1 for all four) (Figure 3.1E). These companies are following the legal requirements for good practices but have no formal self-checking certified by the Belgian government. The control and assurance activities in the farm butcheries are based on historical and company own information (level 1) and not on sector information provided via national agreed guides per sector on HACCP and best practices , which would allow the butcheries to achieve a level 2.

The assigned scores for system output indicate that the affiliated butcher shops dispose of more information on the performance of their FSMS (e.g. internal information, information of external audits…) (assigned score 2 for the system output) than the short chain farm butcheries (assigned score 0 for FB1 and FB2, 1 for FB3 and FB4) (Figure 1F). The relation between the context riskiness and the level of the current FSMS can be interpreted, according to the reasoning of Luning et al. (2015) in a cross European study in animal production (meat and dairy), of Sampers et al. (2012) in the dairy industry in Japan and of Sampers et al. (2010) in the Belgian poultry industry. In these studies, the authors state that companies with a high-risk context require a FSMS which is on a higher level (meaning more tailored and adapted to the company's own situation) in order to be able to obtain a high level in system output and eventual food safety and hygiene.

In this case study, it can be concluded that this is the case for the affiliated butcher shops but not for the short chain farm butcheries, where the high risk context is not compensated by a fit-for-purpose FSMS, resulting in a poor system output as these short chain farm butcheries have no insight in their performance. However, this does not mean that the actual microbiological hygiene and safety of processed meat and environmental hygiene are not appropriate which is further investigated by microbiological samples taken in those butcheries. The question arises here whether these short chain farm butcheries need to elaborate their FSMS at a higher level (e.g. fit-for-purpose procedures, HACCP principles, monitoring CCPs, etc…) to achieve an appropriate level of food safety and hygiene and/or whether human aspects (more personally accountable, connected to customers, see section 3.3.1) can counterbalance the shortcomings in these more formal features of food safety performance. The fact that these farm butcheries are more closely connected to their customers, might decrease the need for formal written procedures for all food safety and hygiene related tasks, as, for example, employees might be inclined to work in a food safety and hygienic way, ‘because it is the right thing to do’, to ensure food safety of the meat products sold to their customers. Although, a certain fundamental management and procedural structure is considered necessary, as the lack of “a clear management structure to enforce food safety measures”, was considered as one of the causes in the John Barr *E.coli* O157 outbreak in UK (see section 3.1) (Pennington, 2014). Also, it should be noted that it is not expected that employees will counterbalance for bad technical procedures.

3.3.3 Microbiological hygiene and safety

3.3.3.1 Minced beef meat

Table 3.5 shows the results for the microbiological hygiene and safety of the minced beef meat sampled in all affiliated butcher shops and small scale butcheries over the three visits. Also the percentage of samples exceeding the criteria (threshold (tolerance) values for total psychrotrophic count, *E. coli*, *S. aureus*, *Salmonella* spp., *L. monocytogenes*, *E. coli* O157:H7 as given in Table 3.2 and temperature) is given. Looking at the hygiene indicators of the short chain farm butcheries, it can be seen in Table 3.5 that *E. coli* and *S. aureus* are absent or only present in low numbers (< 10 cfu/g) for most of the butcheries, except for FB4 and FB1, where *E. coli* (FB4) and *S. aureus* (FB1 and FB4) were frequently detected, sometimes in higher numbers (*E. coli* overall range: <1.0-2.04 log cfu/g; *S. aureus* overall range: <1.0-2.20 log cfu/g). However, threshold values for *E. coli* and *S. aureus* were never exceeded. For *S. aureus* FB4 had significantly higher counts than FB2. For the affiliated butcher shops, it can be stated that *E. coli* and *S. aureus* are absent or present in low numbers (*E. coli* overall range: <1.0-1.48 log cfu/g; *S. aureus* overall range: <1.0-1.0 log cfu/g). Here also, no threshold values were exceeded. Looking at *E. coli* and *S. aureus* counts in literature showed similar results. Eisel, Linton, and Muriana (1997), reported *E. coli* counts in ground beef products in the United States ranging from 1 to 2 log cfu/g. Counts reported by Gill, McGinnis, Rahn, and Houde (1996) on beef meat for hamburger production in the United States ranged from 0.15 to 2.58 log cfu/g. Scanga, et al. (2000) report *E. coli* counts between 1.0 and 1.9 in ground beef and *S. aureus* was generally not detected (<1 log cfu/g) (also US result).

For total aerobic count Kammenou, Metaxopoulos, and Drosinos (2003) report values ranging from 6.20-6.84 log cfu/g, which lies within the range found in our case study (overall range for AB and FB: 4.24-7.37 log cfu/g). However, results reported by Eisel et al. (1997) in ground beef and Gill et al. (1996) in beef for hamburger production are slightly lower (average of 4.7 log cfu/g and range from 3.54-4.86 respectively). Within the farm butcheries again FB2 had significantly lower counts than FB4 (Table 3.5). Exceedance of the threshold value for total psychrotrophic count (6 log cfu/g) can be seen in 2 of 6 samples for FB1 and in all samples for FB4 (4/4). Within the affiliated butcher shops no significant differences were found, but two of the four butcher shops had samples exceeding the threshold value of 6 log cfu/g: 4 of 6 samples for AB1 and 3 of 4 samples for AB3. Important to note is that total aerobic counts and lactic acid bacteria counts are similar, which suggests that overall contamination is dominated by lactic acid bacteria and few or no other gram negative spoilage organisms are present (e.g. *Pseudomonas, Acinetobacter*…).

L. monocytogenes was detected in the minced beef meat of three of the four short chain farm butcheries (13 of 28 samples in total) and two of the four affiliated butcher shops (3 of 22 samples in total) (Table 3.5). *L. monocytogenes* is typically linked to food processing environments (Belessi, Gounadaki, Psomas, & Skandamis, 2011). It can survive on processing equipment and food contact surfaces (Gandhi & Chikindas, 2007) and act as a continuous source of contamination in the company (Kells & Gilmour, 2004; Lahou & Uyttendaele, 2014). However, this pathogen can also be present in healthy cattle (EFSA, 2014; Nightingale et al., 2004). This means that it would also be possible that *L. monocytogenes* was already present in the beef carcasses or parts that were used for making minced beef, and thus that the contamination with this pathogen took place in the slaughterhouse and not in the butchery (Lahou, Jacxsens, Daelman, Van Landeghem, & Uyttendaele, 2012). Scanga et al. (2000) also indicate *L. monocytogenes* as a pathogen of concern in ground beef products. They report an incidence of 13% in ground beef samples from a ground beef processing plants the United States and therefore suggest ground beef processors to implement sanitation and manufacturing procedures that focus on reducing the levels of this pathogen in ground beef. Jemmi and Stephan (2006) report a prevalence of 28% in minced meat from Denmark (Skovgaard & Morgen, 1988), of 11% in minced meat from Switzerland (Fantelli & Stephan, 2001) and 12% in minced beef meat from Japan (Inoue et al., 2000). *Salmonella* spp. and *E. coli* O157:H7 were never detected in the 28 samples taken from the farm butcheries, nor in the 22 samples taken from the affiliated butcher shops.

Table 3.5: Count range of microbiological results and temperature range for minced beef meat over the three visits per butchery.

Butcheries	Count range in log cfu per g or presence per 25 g of minced beef meat (fraction above legislative or recommended criteria)								Temperature range (°C) (fraction above legal limit of 2°C (EU Regulation 853/2004))	Percentage of exceedance of criteria (%)
	Hygiene indicators		Overall contamination		Pathogens, A: absent, P: present					
	E.coli	*S. aureus* (C+)*	Total aerobic count	Lactic acid bact.	*Salmonella* spp.	*E. coli* O157:H7	*L. monocytogenes*			
							A	P		
FB1	<1 (0/6)	<1-2.20 (0/6)	4.49-7.37 (2/6)	4.27-7.33	A (0/6)	A (0/6)	6/6	0/6	-2.4-2.4 (2/6)^{a}	9.52
FB2	<1 (0/12)^{a}	<1-1.45 (0/12)^{a}	4.60-5.63 (0/12)^{a}	4.08-5.61 ^{a}	A (0/12)	A (0/12)	5/12	7/12	3.7-7.5 (12/12)^{b}	22.62
FB3	<1-1.30 (0/6)	<1 (0/6)	5.16-5.52 (0/6)	4.16-5.06	A (0/6)	A (0/6)	0/6	6/6**	frozen	16.67
FB4	1.85-2.04 (0/4)^{b}	1.26-2.05 (0/4)^{b}	6.91-7.17 (4/4)^{b}	6.30-6.56 ^{b}	A (0/4)	A (0/4)	3/4	1/4	-1.2-(-0.2) (0/4)^{a}	17.86
AB1	<1-1.30 (0/6)	<1 (0/6)	5.32-6.60 (4/6)	5.31-5.99	A (0/6)	A (0/6)	6/6	0/6	0.2-5.0 (2/6)	14.29
AB2	<1-1.00 (0/6)	<1 (0/6)	4.24-5.79 (0/6)	4.21-6	A (0/6)	A (0/6)	6/6	0/6	4.0-6.9 (6/6)^{2}	14.29
AB3	<1-1.48 (0/4)	<1 (0/4)	5.97-6.18 (3/4)	5.56-5.73	A (0/4)	A (0/4)	3/4	1/4	3.5-4.3 (4/4)	28.57
AB4	<1 (0/6)	<1-1.00 (0/6)	4.88-5.96 (0/6)	4.41-5.95	A (0/6)	A (0/6)	4/6	2/6	2.0-3.8(4/6)^{1}	16.67

Statistical significant differences within the farm butcheries (FB) are indicated by different letters in superscript (a < b). Statistical differences within the affiliated butcher shops (AB) are indicated by different numbers in superscript (1 < 2).(Kruskal-Wallis: $p < 0.05$; Mann-Whitney U: $p < 0.008$).

*: Pooled values of AB significantly lower than pooled values of FB ($p < 0.05$)

A: absent

P: Present, Uncountable (<1 log cfu/g) except when indicated with **

** 1/6 countable: 1 log cfu/g

The legal limit of 2°C for temperature (EC., 2004c) was exceeded in some or all of the minced meat samples of the different butcheries, except for FB4 where the legal limit was never exceeded and for FB3 where the meat was sold frozen. Within the farm butcheries FB2 had significantly higher temperatures than FB1 and FB4 ($p < 0.008$). Within the affiliated butcher shops meat temperatures of AB4 were significantly lower than AB2 ($p = 0.002$). Important to mention here is that it is not possible to achieve temperatures below 2°C immediately after mincing. As samples were taken in the morning, it is possible that the meat was freshly minced and temperatures were still higher.

Comparing the farm butcheries with the affiliated butcher shops showed that *S. aureus* counts were significantly higher in the farm butcheries than in the affiliated butcher shops ($p = 0.007$). For *E. coli* no significant difference was detected ($p = 0.209$). Thus, based on hygiene indicators it can be stated that the affiliated butcher shops are performing slightly better than the farm butcheries, although no criteria are exceeded. For total count and lactic acid bacteria (overall contamination) no significant differences were detected ($p > 0.05$), so for overall contamination farm butcheries and affiliated butcher shops are on a similar level. Also temperatures of the minced meat samples can be considered similar ($p = 0.751$). Considering pathogens *E.coli* O157 and *Salmonella* spp. were never detected in both types of butcheries, but *L. monocytogenes* was detected in 46.43% of the samples of the farm butcheries and only in 13.64% of the samples of the affiliated butcher shops. So here again, the affiliated butcher shops are performing better. Based on the percentage of exceedance of the microbiological criteria and legal limit for temperature of raw minced beef meat, the different butcheries can be ranked as follows: AB3 < FB2 < FB4 < FB3 and AB4 < AB1 and AB2 < FB1 (worse to better microbiological results).

3.3.3.2 Environmental swabs

L. monocytogenes was never detected in the environment of FB2 (in total 0/15 swabs), which suggests that the *L. monocytogenes* found in the minced beef meat, was present through contamination in the slaughterhouse. In FB1 and FB3 *L. monocytogenes* was detected frequently (FB1: in total 5/15 *L. monocytogenes* swabs; FB3: in total 9/15 *L. monocytogenes* swabs), which indicates insufficient cleaning and disinfection. In FB1 *L. monocytogenes* was present on wheels of containers/chariots in two of three visits and in the drain gate on all visits. For FB3 *L. monocytogenes* was found in one of three visits on a contact surface not in use, two of the three visits in the drain gate and three of three visits on wheels and on a contact surface in use. FB4 can be ranked somewhere in the middle (in total 2/15 *L. monocytogenes* swabs), as *L. monocytogenes* was found in one of three visits in the drain gate and on a contact surface in use. The ranking based on the *L. monocytogenes* swabs is then: FB3 < FB1 < FB4 < FB2. For the affiliated butcher shops, *L. monocytogenes* was only detected in the drain gate of AB4 (two of three visits in the drain gate; in total 2 positive of 15 *L. monocytogenes* swabs) and never in any of the other affiliated butcher shops (in total 0/15 *L. monocytogenes* swabs).

The overall prevalence *of L. monocytogenes* in the environmental samples of our study was 15% (25% for short chain butcheries; 3.33% for conventional chain butcheries). Gudbjornsdottir et al. (2004) report an overall incidence (processing lines and environment, personnel, raw materials and products) in Nordic meat processing plants ranging from 0 to 15%. Conveyor belts, floors, drains and also raw material were identified as problematic sites for *L. monocytogenes* contamination. A prevalence of 1.2% (after cleaning) to 7% (in process) was found on equipment and transporters. On floors and drains a prevalence of 6.5% (after cleaning) to 7% (in process) was reported. In our case study drains could also be identified as a problematic site for *L. monocytogenes* contamination, as it was detected in 33% of the drain gate samples. Also on wheels *L. monocytogenes* was frequently detected (21% of the wheel samples). Peccio, Autio, Korkeala, Rosmini, and Trevisani (2003) swabbed the environment and equipment in a Finish pork processing plant. *L. monocytogenes* was detected in 4% (2/51) of the environmental samples (one kneader sample and one mincer sample). In a Finish bovine slaughterhouse 6.5% (3/46) of the environmental samples were positive for *L. monocytogenes*. The pathogen was found in 3 of 11 knife samples. *L. monocytogenes* was also present on 1 of 14 carcass swabs and 3 of 12 excised meat samples (Peccio et al., 2003). Based on the *L. monocytogenes* detection a general ranking of the different butcheries can be made for environmental swabs: FB3 < FB1 < FB4 and AB4 < AB3 < FB2, AB1, AB2 and AB3.

3.3.3.3 Hand swabs

Table 3.6 shows that no significant differences were detected within the hand swab counts of the short chain farm butcheries ($p > 0.05$). However, FB3 and FB4 can be considered to be on a lower level, as *E. coli* was occasionally detected on the hands of the employees. Although disinfecting soap was used for hand washing in FB3 and FB4, drying was done with a cotton towel and not with disposable paper towels. FB1 and FB2 used not-disinfecting household soap and drying was done with paper towels in FB2 and with a cotton towel in FB1. For the affiliated butcher shops the ranking based on coliform count could be as follows: AB4 < AB1 < AB3 < AB2, as AB4 had some very high coliform counts and AB2 has been found significantly better than AB3 for total aerobic count ($p = 0.005$). In general, it can be concluded that the hand swabs of the affiliated butcher shops had significantly lower counts than the short chain farm butcheries ($p < 0.05$). This could be due to the fact that in all affiliated butcher shops disinfecting soap was used consistently in combination with drying with disposable paper towels.

Table 3.6 Count range of hand swabs over all three visits.

Butcher-ies	Count range on hands in log cfu per 50 cm² (fraction above limit of detection)		
	Hygiene indicators		
	E.coli*	**Coliforms***	**Total aerobic count***
FB1	<0.70 (0/3)	<0.70-1.40 (1/3)	4.45-4.93 (3/3)
FB2	<0.70 (0/7)	<0.70-2.47 (3/7)	3.69-6.60 (7/7)
FB3	<0.70- 1.95(4/17)	<0.70-4.27 (13/17)	4.18-6.41 (17/17)
FB4	<0.70-1.70 (4/10)	<0.70-3.21 (6/10)	4.88-6.23 (10/10)
AB1	<0.70 (0/7)	0.70-1.85 (4/7)	3.60-6.00 (7/7)
AB2	<0.70 (0/11)	<0.70-1.18 (1/11)	<0.70-5.09 (11/11)^{1}
AB3	<0.70 (0/6)	<0.70-1 (1/6)	4.04-5.58 (6/6)^{2}
AB4	<0.70 (0/8)	<0.70-3.09 (3/8)	1.70-5.61 (8/8)

Statistical significant differences within the farm butcheries (FB) are indicated by different letters in superscript (a < b).
Statistical differences within the affiliated butcher shops (AB) are indicated by different numbers in superscript (1 < 2).
(Kruskal-Wallis: $p < 0.05$; Mann-Whitney U: $p < 0.008$).
*: Pooled values of AB significantly lower than pooled values of FB ($p < 0.05$)

In a study of Lahou et al. (2012) in a food service operation (eight university restaurants and eleven cafeterias) gloves or hands of food handlers were swabbed. *E. coli* was never detected and total aerobic count values ranged from <1.0 log cfu/ 50 cm² to 4.3 log cfu/ 50 cm², which is lower than the counts found in our case study (overall range: <0.70-6.60 log cfu/ 50 cm²). Moreover, *E. coli* was found in eight of 69 hand swabs in our case study. However, in our study, employees are continuously handling raw meat which was not the case in the food service operation where salads, soups, sandwiches and hot meals are served. Oses et al. (2012b) report higher total count values on operator hands in their study in which they investigated five butcheries in the lamb chain. Their total aerobic count values for hand swabs ranged from <2.7 log cfu/ 50 cm² to 5.1 log cfu/ 50 cm², which corresponds more with the values in the current study. However, *E. coli* was never detected on the food handler's hands in the study by Oses et al. (2012b), whilst we detected *E. coli* on eight of 69 hand swabs.

3.3.4 Food safety culture

In Figure 3.2 farm butcheries and affiliated butcher shops were ranked relative to each other for the different aspects of food safety culture which were assessed, being the level of the FSMS (and its context and system output assessed by means of the diagnostic instrument), perceived food safety climate and level of food safety and hygiene. As the food safety climate score of the affiliated butcher shops was significantly higher than the farm butcheries and no significant differences were found within these two types of butcheries, two groups can be considered for the ranking of the food safety climate. Affiliated butcher shops are ranked higher than the farm butcheries. Also for context riskiness, FSMS and system output affiliated butcher shops could be ranked as one group opposed to the farm butcheries as another group based on the assigned scores. It can be seen from Figure 3.2 that the affiliated butcher shops are able to counter the risky context (high level of risk towards microbiological contamination) by a well elaborated and fit-for-purpose FSMS (high level), whilst the farm butcheries have a more basic FSMS (lower level), based on the principles of the diagnostic tool applied for this aspect of food safety culture (Luning et al., 2015). Moreover, the farm butcheries have no information available about their system output, whilst the affiliated butcher shops do know where their weaker points are by follow up of product sampling, complaints, audits, etc. Based on the microbiological results of the minced beef meat, the environmental swabs and the hand swabs, farm butcheries were for most of the parameters at a lower level than the affiliated butcher shops (as presented in Figure 3.2). In order to obtain a visual overview of the level of food safety and hygiene in each of the butcher shops for the meat, environmental swabs and hand swabs separately, the percentage of conformity is calculated as explained in section 3.2.6 and presented in Figure 3.3. However, it should be noted that presence of *E.coli* on hands is no legal criterion, but is used to allow calculation of a percentage to compare the butcheries.

Level

FSClimate	Context		FSMS	System output	Level of MO hygiene and safety
	Prod/Pro	Org/Ch			Overall:
AB (91.93%)	AB+FB (2_3)	FB (2_3)	AB (2_3-3)	AB (2)	AB (Figure 3.3)
FB (83.26%)		AB (1_2)	FB (1)	FB (0 or 1)	FB (Figure 3.3)

Figure 3.2: Relative ranking of the eight butcheries included in the case study for their food safety climate, context riskiness, food safety management system (FSMS), system output and microbiological (MO) hygiene and safety. AB: all affiliated butcher shops; FB: all farm butcheries. Prod/Proc: product and process related context characteristics; Org/Ch: organization and chain related context characteristics. Between parentheses percentage of responses equal to 4 'agree' or 5 'totally agree' (sum of '4' and '5') are given for the food safety climate score, and assigned scores for context, FSMS and system output. Overall ranking for MO hygiene and safety is based on Figure 3.3.

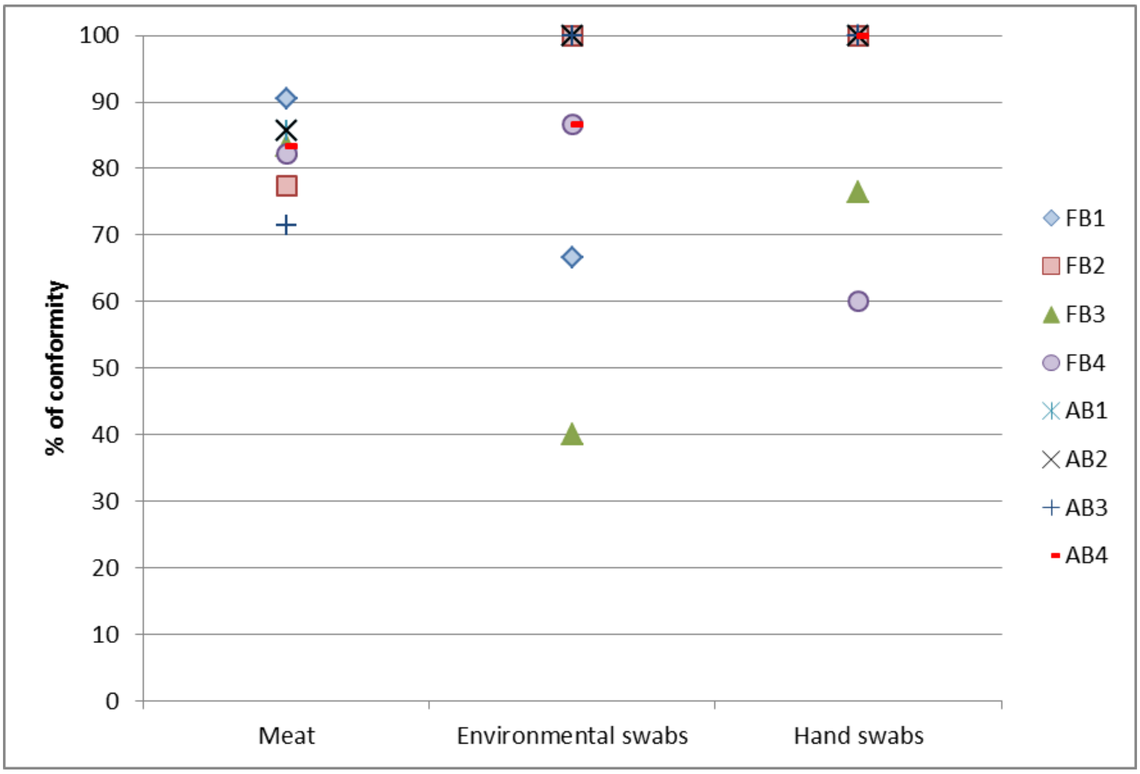


Figure 3.3: Visual overview of the level of food safety and hygiene in each of the butcher shops for the meat, environmental swabs and hand swabs separately, represented as the percentage of conformity for each of the butcheries. FB: Farm butcheries; AB: Affiliated butcher shops.

Looking at the link between these aspects of food safety culture in Figure 3.2 (and Figure 3.3), it can be seen that the affiliated butcher shops have a higher food safety climate score and a more elaborated/fit-for-purpose FSMS, which results in an overall higher microbiological hygiene and safety status than the farm butcheries (except for the microbiological results of the meat in AB3).

This means that employees in the affiliated butcher shop perceive that the leadership, communication, commitment, availability of resources and risk awareness related to food safety in their organization are on a (very) good level, which is confirmed by the fact that the level of food safety and hygiene of the food products and the environment is also at a high level (based on microbiolgocial analysis). As stated in our definition of food safety culture and the food safety culture conceptual model (Figure 1.3), we assume that there is an interplay between the human and techno-managerial route, suggesting that both the high (perceived) level of the food safety climate and the well-elaborated FSMS can be responsible for the high level of food safety and hygiene and that both routes are supporting and interacting with each other. In case of the farm butcheries, perceived food safety climate scores, although these were lower than scores in the affiliated butcher shops, were also on a high level (83.26% of responses equal to 4 ‘Agree’ or 5 ‘Totally agree’). Concerning the techno-managerial route, the FSMS in the farm butcheries was more basic without having any information about the performance of their FSMS (system output). The result of the interaction of both routes (human route and techno-managerial route), is for most parameters a lower level of hygiene and safety of the food products, production environment and hand swabs. The usefulness of setting-up and implementing a FSMS, based on good practices and HACCP principles, in small scale companies is often discussed in literature (e.g. Luning et al. (2015);Jacxsens et al. (2015)). However, the question can be raised whether a basic FSMS can be sufficient in certain cases, e.g. for FB1 in this study, as FB1 is able to achieve a high level of microbiological hygiene and safety with respect to the raw minced beef meat and the hand swabs. But this result should be interpreted with caution as 5 of 15 environmental swabs tested positive for *L. monocytogenes* in this butchery, whereas for the environmental swabs of the affiliated butcher shops *L. monocytogenes* was only detected twice over all butcher shops. This shows that for the farm butcheries, so also for FB1, there is still room for improvement, especially concerning cleaning and disinfection and personnel training, both belonging to elementary good practices. Therefore, the farm butcheries should strive to improve the basic prerequisites, e.g. cleaning and disinfection. Furthermore, FB2 is performing well with respect to environmental swabs and handswabs, but Table 3.5 suggests that this farm butchery has issues with temperature control and presence of *L.monocytogenes* in the raw minced beef meat. Still, although the issues in food safety and hygiene which were noticed as described above, the farm butcheries perceive food safety climate to be on a good level. This might indicate that employees in the farm butcheries are not aware of the food safety issues at their workplace, suggesting that optimistic bias or complacency ("self-satisfaction especially when accompanied by unawareness of actual dangers or deficiencies"(Signore, 2010)) might exist among the farm butchery employees.

3.4 Conclusion

The food safety climate self-assessment tool, as described in chapter 2, showed its usefulness and applicability in this case study in the meat distribution sector. The four short chain farm butcheries and four affiliated butcher shops which were included in the case study, are all operating in a risky microbiological context because of the nature of the products they deliver. The affiliated butcher shops can counteract this risky context by their well elaborated and fit-for-purpose FSMS, whereas the FSMS of the farm butcheries is only basic and not tailored to the company-own situation.

The food safety climate was scored significantly higher in the centrally managed butcher shops compared to the independent small scale farm butcheries. Statistical analysis showed that communication and leadership concerning food safety and hygiene is perceived significantly better in the affiliated butcher shops, which indicates that the negative consequences of the larger organizational size and delocalization of the different affiliates are adequately managed by the central management by for instance regular communication and/or effective leadership behavior which might improve hygiene and food safety behavior among employees. However, although food safety climate was scored lower in farm butcheries, food safety climate was perceived to be on a good to very good level in both types of fresh meat selling points, as 91.93% of the responses of affiliated butcher shop employees and 83.26% of responses of the farm butchery employees were 4 'Agree' or 5 'Totally agree'.

The high (perceived) level of food safety climate by the affiliated butcher shop employees, was confirmed by the high level of microbiological hygiene and safety of the products and production environment in the affiliated butcher shops. The lower level of food safety and hygiene of the farm butcheries might be linked to the lower level of the FSMS and the need to invest further in proper implementation of good practices. As such, the stronger connection with customers and personal accountability which is expected to be present in the farm butcheries, could not counteract the lower level of the FSMS in this case study, as microbiological analysis revealed that the farm butcheries need to improve their basic prerequisites (e.g. cleaning and disinfection). Moreover, the fact that farm butchery employees still perceived the food safety climate to be on a high level, could indicate that optimistic bias or complacency exists, as they are not aware of the food safety and hygiene issues in their organization. Important to note is that results should be interpreted with caution because of the small sample size of this study as the presented work is an exploratory qualitative in-depth study.

Chapter 4

Quantitative study of food safety climate in Belgian food processing companies in view of their organizational characteristics

Redrafted from:

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Abstract

In this chapter the potential impact of organizational characteristics was studied in a more quantitative nation-wide study (opposed to the in-deth case study as presented in chapter 3). The food safety climate in the Belgian food processing industry was investigated and correlations between food safety climate and organizational (general and quality-related) characteristics of food processing companies were assessed. Additionally, the factorial validity of the applied food safety climate assessment tool (presented in chapter 2) was investigated, using exploratory factor analysis. Data were gathered through an online survey available in Dutch and French. Overall, the food safety climate was perceived to be on a good level for most of the 136 responding companies. Companies with multiple sites in Belgium appeared to perceive the food safety climate better than one-site companies. Food companies providing more than one training session per year appeared to perceive their food safety climate significantly better than companies providing less training ($p < 0.001$). For the other organizational characteristics investigated (such as company size, sector, presence of quality department, time spent on quality control, certification, available budget for maintaining the FSMS) no significant correlations with the food safety climate could be proven. Exploratory factor analysis revealed the existence of 4 underlying factors: factor 1 mainly dealing with 'leadership related' indicators, factor 2 with 'resources related' indicators, factor 3 with 'communication related' indicators and factor 4 is a mix of mainly 'risk awareness related' indicators and some 'commitment related' indicators. The five dimensions (leadership, communication, commitment, resources and risk awareness) of food safety climate, as defined in section 1.4.2 were only partly reflected in the extracted factor solution. Still, as results provide evidence that these factors are correlated, it might be that defining completely distinct components/factors is rather difficult.

4.1 Introduction

As illustrated in section 1.1.3, literature studying FSMSs and its performance is already widely present. Both system and product related assessment methods and, more recently, people related assessment methods are used. Also the impact of organizational characteristics on the FSMS is already widely studied, as discussed in section 1.1.2 (e.g. Kirezieva, Nanyunja, et al. (2013)). As stated in section 1.1.2, following definition is adopted: "Organizational characteristics are features originating both from the management model adopted by the organization, through its structure or strategy and, from the company culture embodied in the nature of its membership and relationships" (Simon, 1976). In the current chapter a distinction is made between general organizational characteristics, which are more related to e.g. structure, size and sector, and quality-related organizational characteristics, which are specifically linked to how the quality or food safety management is organized (e.g. certification status, quality team size). Instead of only focusing on the FSMS, recent studies even take one step further with assessment of food safety culture and climate in food companies. However, assessment of food safety climate in food processing companies on a large/nation-wide scale is not yet performed, neither is the relation between food safety climate and key organizational characteristics studied. A great deal of food safety culture/climate studies deal with development and validation of conceptual frameworks and tools (e.g. Jespersen, Griffiths, et al. (2017); Nyarugwe et al. (2016)) or are case studies focusing on one or a few companies (e.g. Griffith, Jackson, and Lues (2017); Jespersen and Huffman (2014)). Although lacking in food processing, in food services Fatimah, Strohbehn, and Arendt (2014) involved 37 health care and 24 school food service operations to investigate the link between food safety culture perceptions and demographic and organizational characteristics. In line with the mentioned research voids, the current paper focuses on food safety climate and its potential relation to characteristics of food processing companies at a national level.

In Chapter 3, a single case study was performed, investigating the potential impact of company size and structure on food safety culture. More specifically in the in-depth case study from chapter 3, the food safety culture of independent micro scale farm butcheries was assessed and compared with food safety culture in centrally (corporate) managed butcher shops. Results suggested that certain organizational characteristics might influence both food safety climate and the eventual food safety and hygiene of the products, as these two types of butcheries were very different in both general and quality related organizational characteristics. Also Nyarugwe et al. (2016) pointed out that several organizational and administrative characteristics (e.g. communication style, training frequency) and FSMS characteristics (e.g. design and assurance of crucial controls), together

generally belonging to the 'quality-related organizational characteristics' as defined by Simon (1976) and used throughout this manuscript, should be taken into account in food safety climate research.
In this chapter, instead of performing a single case-study, the food safety climate was investigated in the Belgian food processing industry, in order to assess the level of the perceived food safety climate and to investigate the link of food safety climate with organizational (general and quality-related) characteristics of food processing companies. As perceptions are measured through the food safety climate self-assessment tool, the focus will be on food safety 'climate' throughout the whole chapter. Additionally, the factorial validity of the applied food safety climate assessment tool was investigated, using exploratory factor analysis (Balcar, 2013). As such, it can be investigated whether the factors/dimensions obtained through exploratory factor analysis are reflecting the five dimensions as defined in our definition of food safety climate (being leadership, communication, commitment, resources and risk awareness).

4.2 Material and methods

4.2.1 Questionnaire design and dissemination

The questionnaire was composed of two sections. One section dealing with organizational characteristics (general and quality-related) and one section assessing the food safety climate. The first section of the survey consisted of multiple choice questions related to organizational characteristics of the food companies. This part was based on expert discussions between scientists of the Department of Food Technology, Safety and Health and the Department of Personnel management, Work and Organizational Psychology of Ghent University, and also the Belgian Association of the Food Industry (FEVIA) was consulted. General organizational characteristics which were deemed relevant are: (inter) national company with multiple sites , multiple sites in Belgium , organizational size (number of full-time equivalents, FTE) and sector. Quality-related organizational characteristics which were added are the following: presence of a quality department, size of quality team (FTE), time spent on quality control, certification status, yearly budget available for maintaining the FSMS and frequency of food safety training. Tables 4.1 and 4.2 contain for each variable the response categories (complete survey: see Appendix 4.A).

The second section of the survey consisted of the 28 indicators/statements of the food safety climate self-assessment tool, as described in chapter 2. The indicators and answer scale were constructed in a way that a higher score on the answer scale (higher agreement with statements) corresponds with a better perceived food safety climate in the company.

Internal consistencies (Cronbach's a) of the component scales and the total food safety climate scale were respectively: 0.92 (leadership), 0.84 (communication), 0.90 (commitment), 0.84 (resources), 0.88 (risk awareness) and 0.97 (total food safety climate) (IBM SPSS version 23 - Chicago, Illinois).

The tool could be filled out through a link to an online survey (SurveyMonkey®) and was available in Dutch and French. A short introduction was added in order to give some explanation about the research and it was mentioned that surveys should be filled out by the quality manager, plant manager or production manager and only one survey per production site could be submitted. In order to reach as many Belgian food processing companies as possible, the Belgian Association of the Food Industry (FEVIA) was contacted and helped with the dissemination by posting the link to the online survey on their website. However, some micro and small enterprises could still be missed here. Additionally, the link to the online survey was published in VMT Food (Magazine for the Belgian food industry) and food companies from the contact list of our UGent Department were contacted through mail. In total, 156 responses were collected, resulting in 136 valid responses. This number is not a representative sample of the Belgian food industry, however can be seen as a convenient sample of the more proactive companies. This was also stated by Jacxsens et al. (2015) in their study in the Belgian food processing industry, in which 82 respondents, being food business operators, were collected to compare their self-checking systems.

4.2.2 Data processing and analysis

In order to assess the status of the food safety climate in the responding Belgian food processing companies, frequencies were calculated for each response possibility (1→5: totally disagree →totally agree) over all responding companies for all 28 indicators. The total food safety climate score for each respondent was calculated by adding up all indicator scores (score 1 to 5, for 28 indicators in total). This was also done for the indicator scores per component, which gave a total score for each of the five food safety climate components per respondent. T-tests and/or ANOVA (post hoc: Bonferroni) were performed, in order to identify statistical differences in total food safety climate scores and total component scores between clusters. Pearson's Chi Square tests were performed to identify statistical differences in organizational characteristics between clusters. Statistical analysis was done using SPSS Statistics version 23, applying a significance level of 0.05.

Consequently, a hierarchical cluster analysis was executed based on the complete linkage (furthest neighbor) method of the individual scores for each indicator of the food safety climate assessment tool (28 indicators). For each cluster organizational characteristics were compared and statistical differences were investigated.

Factorial validity of the food safety climate assessment tool was tested by subjecting the 28 food safety climate indicators to an exploratory factor analysis with direct oblimin rotation (as correlation between factors can be expected), using the data obtained through the online survey as described above. Cluster analysis and factor analysis were performed using IBM SPSS version 23 - Chicago, Illinois.

4.3 Results

4.3.1 Status of food safety climate in Belgian food processing industry

136 valid responses were collected, of which 77.9% were filled out by the quality manager of the company and 8.1% by the plant manager. Production manager and 'others' (also from management level), accounted for 3.7 and 10.3% respectively. No significant difference was detected between responses of these different types of managers ($p = 0.156$). In Table 4.1 and Table 4.2 an overview of the organizational characteristics of the responding food processing companies is given. To make the data more suitable for statistical analysis, multiple category items were regrouped into fewer overarching categories (Table 4.1 and 4.2). In Table 4.1, the seven categories for 'Total number of FTE' were reduced to two overarching categories: 'less than 50 FTE' and '50 FTE and more', also the 18 categories mentioned in the survey for 'Sector' were reduced to 4 overarching categories: 'Foods of non-animal origin', 'Foods of animal origin', 'Mixed foods', 'Other (e.g. food ingredients, drinks…)' and 'More than one category'. Table 4.1 shows which original multiple item categories were placed in which overarching category (superscripts a, b, c and d, Table 4.1). In Table 4.2, multiple item categories for 'Size of the quality team', 'Number of FTE days per week spent on quality control', 'Yearly budget available for maintenance of the FSMS' and 'Frequency of food safety training' were each reduced to two overarching categories. For quality characteristic 'Certification for standards', 18 multiple item categories were reduced to three overarching categories: 'Certification for multiple standards', 'Certification for one single standard' and 'No certification' (Table 4.2).

An overview of responses for the food safety climate indicators is given in Table 4.3. Over all 28 indicators, most responding companies agreed (50.5%) or totally agreed (24.7%) with the statements, which suggests that most of the responding companies perceive their food safety climate to be on a good to very good level. Moreover, considering the separate indicators, most frequent response possibility was '4: Agree' for all indicators except E3.Table 4.3 shows that a large number of respondents (39.7%) did not agree, nor disagree with statement E3 'In my organization, working in a hygienic and food safe way is recognized and rewarded'. Moreover, the responses were more spread over the different response possibilities for this indicator.

Table 4.1: General organizational characteristics of responding companies (n=136). For 'total number of FTE' and 'Sector' multiple item categories from the survey were regrouped in fewer overarching categories in order to facilitate analysis.

	Multiple item Cat.	Frequency (Percentage)	Multiple item Cat.	Frequency (Percentage)	Overarching Category	Frequency (Percentage)
Part of (inter) national company with multiple sites	Yes	78 (57.4)				
	No	58 (42.6)				
Multiple sites in Belgium	Yes[1,2]	55 (40.4)				
	No	80 (58.8)				
Total number of FTE	0 FTE	0 (0)	20-49 FTE	34 (25)	<50 FTE (micro and small) (EU Reg 361/2003)	42 (30.9)
	1-4 FTE	1 (0.7)	50-99 FTE	25 (18.4)	≥50 FTE (medium and large)	94 (69.1)
	5-9 FTE	3 (2.2)	≥100 FTE	69 (50.7)		
	10-19 FTE	4 (2.9)				
Sector* (multiple answers possible)	1[a]	26 (19.1)	10[b]	11 (8.1)	Foods of non-animal origin	57 (41.9)
	2[a]	18 (13.2)	11[b]	8 (5.9)	Foods of animal origin	50 (36.8)
	3[a]	8 (5.9)	12[c]	15 (11.0)	Mixed foods	9 (6.6)
	4[a]	1 (0.7)	13[c]	3 (2.2)	Other (food ingredients…)	10 (7.4)
	5[a]	10 (7.35)	14[d]	1 (0.7)	More than one category	10 (7.4)
	6[a]	3 (2.2)	15[d]	2 (1.5)		
	7[b]	3 (2.2)	16[d]	2 (1.5)		
	8[b]	11 (8.1)	17[d]	9 (6.6)		
	9[b]	28 (20.6)	18[a]	3 (2.2)		

*categories for 'sector ' are the following: 1: Processing of potatoes, vegetables and fruits; 2: Confectionery and breakfast cereals; 3: Industrial bread and banquet bakery; 4: Margarine production; 5: Trade in potatoes, vegetables and fruits; 6: Production of natural foods and vegetarian preparations ; 7: Consumption ice industry; 8: slaughterhouses and cutting plants; 9: Meat processing sector; 10: Fish processing ; 11: Dairy industry; 12: Processing of ready-to-eat meals; 13: Production of Deli-salads; 14: Brewery ; 15: Coffee (roasting) and tea; 16: Production of packaged water, soft drinks, juices and nectars; 17: Food ingredients and additives; 18: Other sector than 1-17.

[a]: regrouped in category 'Foods of non-animal origin'; [b]: regrouped in category: 'Foods of animal origin'; [c]: regrouped in category 'Mixed foods'; [d]: regrouped in category 'Other' (e.g. food ingredients, supplements, drinks)

[1]: Significantly higher total food safety climate score than other category (significance level of 0.05); [2]: Significantly higher component score than other category for leadership, communication and commitment (significance level of 0.05)

Table 4.2: Quality-related organizational characteristics of responding companies (n=136). Multiple item categories from the survey were regrouped in fewer overarching categories in order to facilitate analysis.

	Multiple item Category	Frequency (Percentage)	Multiple item Category	Frequency (Percentage)	Overarching Category	Frequency (Percentage)
Quality department present	Yes	122 (89.7)				
	No	14 (10.3)				
Size of the quality team (FTE)	0 or NA	5 (3.7)	16-20	7 (5.1)	< 5 FTE	89 (65.4)
	1-5	89 (65.4)	>20	7 (5.1)	≥ 5 FTE [2]	45 (33.1)
	11-15	11 (8.1)				
Number of FTE days per week spent on quality control	1-10	76 (55.9)	31-40	18 (13.2)	< 11	76 (55.9)
	11-20	23 (16.9)	41-50	0 (0)	≥ 11	57 (41.9)
	21-30	0 (0)	>50	16 (11.8)		
Certification for which standards (multiple answers possible)*	1	1 (0.7)	10	7 (5.1)	Certification multiple standards	114 (83.8)
	2	16 (11.8)	11	1 (0.7)	Certification single standard	21 (15.4)
	3	13 (9.6)	12	104 (76.5)	No Certification	1 (0.7)
	4	69 (50.7)	13	24 (17.6)		
	5	1 (0.7)	14	1 (0.7)		
	6	1 (0.7)	15	6 (4.4)		
	7	1 (0.7)	16	2 (1.5)		
	8	98 (72.1)	17	2 (1.5)		
	9	4 (2.9)	18	1 (0.7)		
Yearly budget available for maintenance of the FSMS	None	4 (2.9)	10000-25000 EUR	29 (21.3)	<10 000 EUR	31 (22.8)
	1000-5000 EUR	9 (6.6)	>25000 EUR	70 (51.5)	>10 000 EUR	99 (72.8)
	5000-10000 EUR	18 (13.2)				
Frequency of food safety training	None	1 (0.7)	1 training/year	75 (55.1)	≤1 training/year (only legal)	80 (58.8)
	<1 training/year	4 (2.9)	> 1 training/year	56 (41.2)	> 1 training/year [1,3]	56 (41.2)

*categories for 'Certification for which standards ' are the following: 1: none; 2: ISO 9001:2015; 3: FSSC 22000; 4: BRC Global Standard for Food Safety; 5: BRC Global Standard for Storage and Distribution; 6: BRC Global Standard for Packaging and Packaging Materials; 7: BRC Global Market; 8: IFS Food; 9: IFS Logistics; 10: GLOBAL GAP; 11: COMEOS Food ; 12: Self checking certification; 13: GMP Plus Feed Safety Assurance/Feed Chain Alliance; 14: GMP Plus Feed Responsibility Assurance; 15: MSC (Marine stewardship Council); 16: Q&S; 17: IFS Broker; 18: BRC Broker

[1]: Significantly higher total food safety climate score than other category (significance level of 0.05); [2]: Significantly higher total component score for commitment than other category (significance level of 0.05); [3]: Significantly higher total component score for all separate components (leadership, communication, resources, commitment and risk awareness) (significance level of 0.05)

Table 4.3: Frequencies in absolute numbers (percentage between brackets) per response possibility (five-point Likert answer scale 1-> 5: totally disagree, disagree, neutral, agree, totally agree) for each of the 28 indicators of the food safety climate assessment tool for all responding companies (n=136). Of the 28 indicators, 6 indicators (L1-L6) belong to component 'Leadership', 5 indicators (C1-C5) to component 'Communication', 6 indicators (E1-E6) to component 'Commitment', 6 indicators (M1-M6) to component 'Resources' and 5 indicators (R1-R5) to component 'Risk awareness'. For total food safety climate, frequencies are given in percentage.

		1	2	3	4	5
Leadership	**L1**	1 (0.7)	6 (4.4)	10 (7.4)	63 (46.3)	56 (41.2)
	L2	2 (1.5)	6 (4.4)	13 (9.6)	76 (55.9)	39 (28.7)
	L3	2 (1.5)	11 (8.1)	38 (27.9)	64 (47.1)	21 (15.4)
	L4		10 (7.4)	15 (11.0)	76 (55.9)	35 (25.7)
	L5	1 (0.7)	6 (4.4)	20 (14.7)	72 (52.9)	37 (27.2)
	L6	2 (1.5)	6 (4.4)	20 (14.7)	63 (46.3)	45 (33.1)
Communica-tion	**C1**		10 (7.4)	13 (9.6)	72 (52.9)	41 (30.1)
	C2	2 (1.5)	5 (3.7)	27 (19.9)	72 (52.9)	30 (22.1)
	C3	1 (0.7)	4 (2.9)	3 (2.2)	70 (51.5)	58 (42.6)
	C4	2 (1.5)	10 (7.4)	29 (21.3)	57 (41.9)	38 (27.9)
	C5		3 (2.2)	22 (16.2)	72 (52.9)	39 (28.7)
Commitment	**E1**	1 (0.7)	9 (6.6)	18 (13.2)	60 (44.1)	48 (35.3)
	E2	1 (0.7)	8 (8.9)	33 (24.3)	70 (51.5)	24 (17.6)
	E3	5 (3.7)	33 (24.3)	54 (39.7)	34 (25.0)	10 (7.4)
	E4	2 (1.5)	12 (8.8)	32 (23.5)	65 (47.8)	25 (18.4)
	E5	2 (1.5)	10 (7.4)	28 (20.6)	70 (51.5)	26 (19.1)
	E6	3 (2.2)	13 (9.6)	33 (24.3)	64 (47.1)	23 (16.9)
Resources	**M1**	2 (1.5)	15 (11.0)	31 (22.8)	67 (49.3)	21 (15.4)
	M2	2 (1.5)	12 (8.8)	30 (22.1)	73 (53.7)	19 (14.0)
	M3		6 (4.4)	26 (19.1)	71 (52.2)	33 (24.3)
	M4		4 (2.9)	23 (16.9)	60 (44.1)	49 (36.0)
	M5	1 (0.7)	8 (5.9)	22 (16.2)	78 (57.4)	27 (19.9)
	M6		1 (0.7)	17 (12.5)	73 (53.7)	45 (33.1)
Risk awareness[1]	**R1**		2 (1.5)	5 (3.7)	77 (56.6)	51 (37.5)
	R2		4 (2.9)	13 (9.6)	83 (61.0)	35 (25.9)
	R3	1 (0.7)	6 (4.4)	33 (24.3)	77 (56.6)	18 (13.2)
	R4	2 (1.5)	5 (3.7)	15 (11.0)	84 (61.8)	29 (21.3)
	R5	2 (1.5)	7 (5.1)	51 (37.5)	59 (43.4)	16 (11.8)
Total FS Climate:		(1.0)	(6.1)	(17.7)	(50.5)	(24.7)

[1] : one respondent did not fill out indicators R1-R5

Regarding the general organizational characteristics, further statistical analyses showed that companies with multiple sites in Belgium have higher overall food safety climate scores than companies with only 1 site ($t=2.454$; $p = 0.015$) (Table 4.1). At food safety component level, total commitment scores appeared to be significantly higher for companies with more than 5 FTE employed in the quality team ($t=-2.115$; $p = 0.036$) and also for companies with multiple sites in Belgium ($t=2.546$; $p = 0.012$). Also total leadership scores and communication scores were significantly higher for multiple-site companies ($p < 0.05$). Interestingly, for the quality related organizational characteristics, highly significant differences in overall food safety climate scores could be found based on training frequency ($t=-4.361$; $p < 0.001$) (Table 4.2). Companies providing more training than 'once per year' tend to have a better overall food safety climate. This was also the case for the total component scores for all five food safety climate components ($p < 0.05$). No significant differences in food safety climate scores were found for the other organizational characteristics (company size, sector, presence of quality department, time spent on quality control, certification, available budget for maintaining the FSMS) ($p > 0.05$).

4.3.2 Cluster analysis

Based on individual indicator food safety climate scores (28 indicators) a hierarchical cluster analysis was performed (Figure 4.1). At highest distance, i.e. the highest dissimilarity level, two clusters could be identified: cluster 1A, consisting of 133 companies and cluster 1B, consisting of 2 companies (29 and 98). Looking more closely at the response pattern of these 2 companies, revealed that 75% of the responses of company 29 and 92% of the responses for company 98 were '1: totally disagree' or '2: disagree'. Rest of the indicators were mainly '3: neutral' or exceptionally '4: Agree'. For cluster 1A modes for all but one (E3) indicator were '4: Agree'. This means that food safety climate is perceived to be on a much lower level in companies 98 and 29, compared to the rest of the responding companies. Focusing on the organizational characteristics of companies 29 and 98, revealed that both are part of (inter)national companies with multiple sites, consisting of more than 50 FTE, and both companies are producing food of animal origin, with certification for multiple standards. The quality team consists of less than 5 FTE and spends less than 11 FTE days per week on quality control for company 29, but more than 11 FTE days per week for company 98. Both companies foresee more than 10 000 EUR per year for maintaining the FSMS and provide ≤ 1 food safety training per year.

At a lower distance in the dendrogram (Figure 4.1), so at a lower dissimilarity level, cluster 1A could be further split up in two clusters: cluster 2A (83 companies) and 2B (50 companies). Table 4.4 shows the response pattern of both clusters on each of the 28 food safety climate indicators and in Table 4.5 organizational characteristics of both clusters are given. Total food safety climate scores and total component scores separately were all significantly different for cluster 2A versus cluster 2B ($p < 0.001$) (Table 4). Companies in cluster 2A perceived the food safety climate to be on a higher level than companies in cluster 2B, as based on Table 4.4, it can be concluded that, for cluster 2A, 6 of the 28 modes are equal to 5 ('5: Totally agree'), while for cluster 2B this is never 5 and here a mode of '3: not agree, not disagree' is quite often found (for 8 indicators of 28).

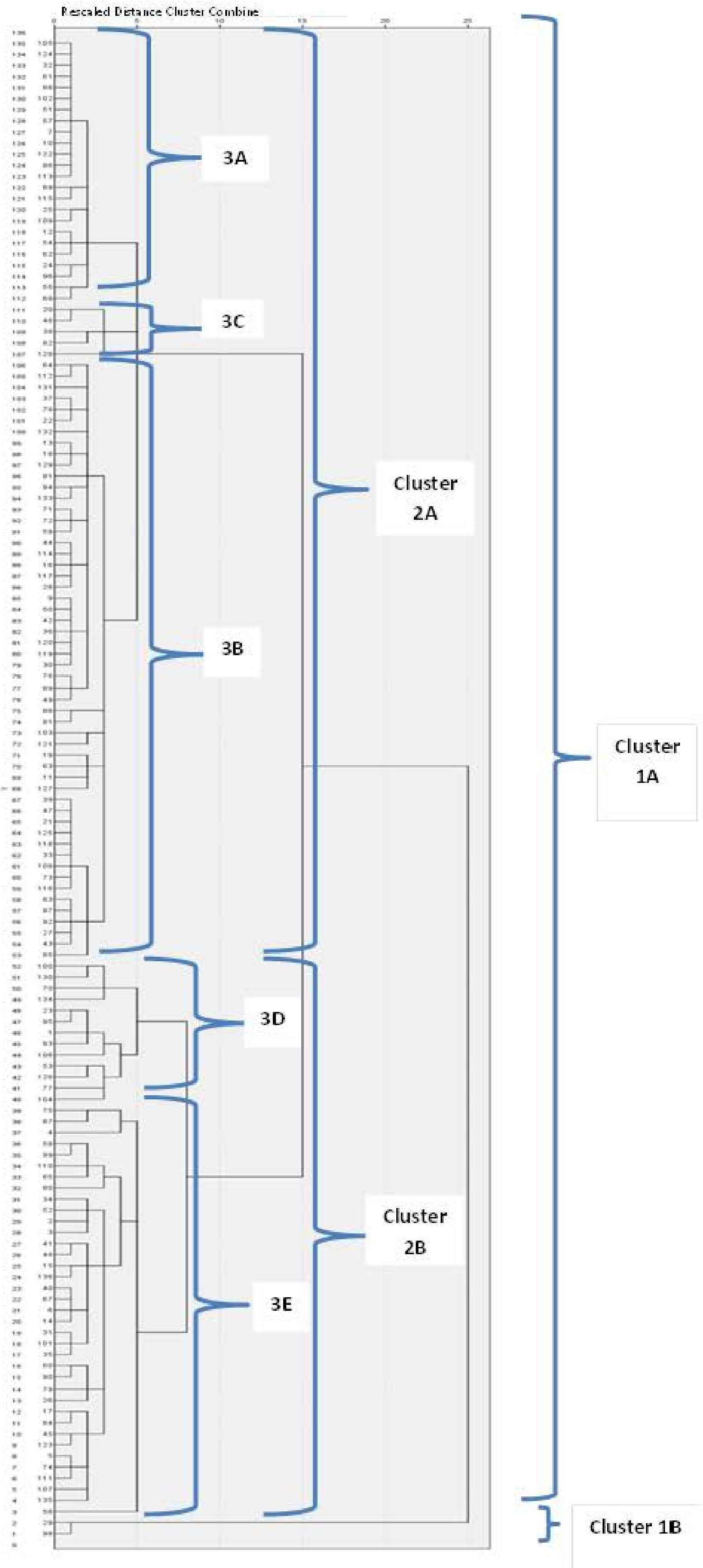


Figure 4.1: Dendrogram analysis of 135 Belgian food processing companies (company 8 was automatically excluded, as part of the food safety climate indicators were not filled out) according to their individual indicator scores of the food safety climate self-assessment tool (28 indicators).

Table 4.4: Frequencies in absolute numbers (percentage between brackets) per response possibility (five-point Likert answer scale 1-> 5: totally disagree, disagree, neutral, agree, totally agree) for each of the 28 indicators of the food safety climate assessment tool for all companies in cluster 2A and cluster 2B. Also modes are given for each indicator.

		Cluster 2A (n=83)						**Cluster 2B (n=50)**					
		1	**2**	**3**	**4**	**5**	**Mode**	**1**	**2**	**3**	**4**	**5**	**Mode**
Leadership*	**L1**			2 (2.4)	33 (39.8)	48 (57.8)	5		5 (10.0)	8 (16.0)	29 (58.0)	8 (16.0)	4
	L2			7 (8.4)	42 (50.6)	34 (41)	4		6 (12.0)	5 (10.0)	34 (68.0)	5 (10.0)	4
	L3		1 (1.2)	10 (12)	51 (61.4)	21 (25.3)	4		10 (20.0)	27 (54.0)	13 (26.0)		**3**
	L4			2 (2.4)	50 (60.2)	31 (37.3)	4		8 (16.0)	12 (24.0)	26 (52.0)	4 (8.0)	4
	L5			5 (6)	42 (50.6)	36 (43.4)	4		5 (10.0)	14 (28.0)	30 (60.0)	1 (2.0)	4
	L6			4 (4.8)	39 (47.0)	40 (48.2)	5		6 (12.0)	16 (32.0)	23 (46.0)	5 (10.0)	4
Communica -tion*	**C1**			5 (6)	41 (49.4)	37 (44.6)	4		8 (16.0)	8 (16.0)	30 (60.0)	4 (8.0)	4
	C2			6 (7.2)	47 (56.6)	30 (36.1)	4		5 (10.0)	21 (42.0)	24 (48.0)		4
	C3				37 (44.6)	46 (55.4)	5		3 (6.0)	3 (6.0)	32 (64.0)	12 (24.0)	4
	C4	1 (1.2)	2 (2.4)	13 (15.7)	35 (42.2)	32 (38.6)	4	1 (2.0)	8 (16.0)	13 (26.0)	22 (44.0)	6 (12.0)	4
	C5			5 (6)	43 (51.8)	35 (42.2)	4		2 (4.0)	16 (32.0)	28 (65.0)	4(8.0)	4
Commitment*	**E1**			4 (4.8)	38 (45.8)	41 (49.4)	5		8 (16.0)	13 (26.0)	22 (44.0)	7 (14.0)	4
	E2			4 (4.8)	56 (67.5)	23 (27.7)	4		7 (14.0)	28 (56.0)	14 (28.0)	1 (2.0)	**3**
	E3		10 (12)	32 (38.6)	31 (37.3)	10 (12)	**3**	3 (6.0)	22 (44.0)	22 (44.0)	3 (6.0)		2-3
	E4		2 (2.4)	11 (13.3)	45 (54.2)	25 (30.1)	4		9 (18.0)	21 (40.0)	20 (40.0)		**3**
	E5			7 (8.4)	52 (62.7)	24 (28.9)	4		10 (20.0)	20 (40.0)	18 (36.0)	2 (4.0)	**3**
	E6			6 (7.2)	54 (65.1)	23 (27.7)	4	1 (2.0)	13 (26.0)	26 (52.0)	10 (20.0)		**3**
Resources*	**M1**			12 (14.5)	51 (61.4)	20 (24.1)	4		14 (28.0)	19 (38.0)	16 (32.0)	1 (2.0)	**3**
	M2		1 (1.2)	15 (18.1)	50 (60.2)	17 (20.5)	4		11 (22.0)	15 (30.0)	22 (44.0)	2 (4.0)	4
	M3		1 (1.2)	4 (4.8)	48 (57.8)	30 (36.1)	4		5 (10.0)	20 (40.0)	22 (44.0)	3 (6.0)	4
	M4		1 (1.2)	7 (8.4)	32 (38.6)	43 (51.8)	5		3 (6.0)	14 (28.0)	27 (45.0)	6 (12.0)	4
	M5		1 (1.2)	8 (9.6)	49 (59.0)	25 (30.1)	4		6 (12.0)	14 (28.0)	29 (58.0)	1 (2.0)	4
	M6			4 (4.8)	44 (53.0)	35 (42.2)	4		1 (2.0)	13 (26.0)	27 (54.0)	9 (18.0)	4
Risk awareness*	**R1**			2 (2.4)	36 (43.3)	45 (54.2)	5		1 (2.0)	3 (6.0)	40 (80.0)	6 (12.0)	4
	R2			3 (3.6)	50 (60.2)	30 (36.1)	4		3 (6.0)	9 (18.0)	33 (66.0)	5 (10.0)	4
	R3			5 (6.0)	60 (72.3)	18 (21.7)	4		5 (10.0)	28 (56.0)	17 (34.0)		**3**
	R4			2 (2.4)	54 (65.1)	27 (32.5)	4		5 (10.0)	13 (26.0)	30 (60.0)	2 (4.0)	4
	R5			19 (22.9)	48 (57.8)	16 (19.3)	4		7 (14.0)	32 (64.0)	11 (22.0)		**3**

*significant difference between cluster 2A and 2B on a 0.05 significance level for total component score: p <0.001; also total food safety climate scores: p <0.001

Companies in cluster 2B also chose more often for '1: Totally disagree' or '2: Disagree' as a response. Table 4.5 provides evidence that cluster 2A has significantly more companies which are part of an (inter)national company with multiple sites, which have yearly budget for maintaining the FSMS of more than 10 000 EUR and which provide more than 1 food safety training per year ($p < 0.05$). Indeed, from Table 4.5 it can be concluded that only 14% of the companies in cluster 2B are giving more than 1 food safety training session per year, compared to 50.6% of the companies in cluster 2A. Still, this means that within cluster 2A, there is still a subgroup (49.4% of cluster 2A) of companies providing less training but still managing to have higher food safety climate scores. This might suggest that providing less than one food safety training session per year, does not necessarily implicate that the company will have a lower food safety climate score, as also other variables, such

Table 4.5: Frequencies in absolute numbers (percentage between brackets) for questions related to organizational characteristics for all companies in cluster 2A and cluster 2B.

Variable	Categories	Cluster 2A n=83	Cluster 2B n=50
Part of (inter)national	-Yes	53 (63.9)	23 (46)
company*	-No	30 (36.1)	27 (54.0)
Multiple sites in Belgium	-Yes	38 (45.8)	16 (32.0)
	-No	44 (53.0)	34 (68.0)
		1 missing	
Total number of FTE	-<50	25 (30.1)	16 (32.0)
	->50	56 (69.9)	34 (68.0)
Sector	-Food of animal origin	28 (33.7)	20 (40.0)
	-Food of non animal origin	41 (49.4)	16 (32.0)
	-Mixed foods[a]	4 (4.8)	4 (8.0)
	-Others (e.g. food ingredients)[a]	6 (7.2)	4 (8.0)
	-More than one category[a]	4 (4.8)	6 (12.0)
Quality department	-Yes	76 (91.6)	43 (86.0)
present	-No	7 (8.4)	7 (14.0)
Size of Quality team	-less than 5	51 (61.4)	35 (70.0)
	-5 or more	32 (38.6)	13 (26.0)
			(2 missing)
Number of FTE days/week	-<11	42 (50.6)	32 (64.0)
spent on quality control	-≥11	40 (48.8)	16 (33.3)
		1 missing	2 missing
Certification	-for multiple standards	69 (83.1)	43 (86.0)
	-for a single standard[b]	14 (16.9)	6 (12.0)
	-no certification[b]		1 (2.0)
Yearly budget for FSMS	-< 10 000EUR	14 (16.9)	16 (32.0)
maintenance*	-> 10 000 EUR	65 (78.3)	32 (64.0)
		(4 missing)	(2 missing)
Frequency of food safety	-≤ 1 training per year	41 (49.4)	36 (72.0)
training*	-> 1 training per year	42 (50.6)	14 (28.0)

*variable has a significant association with cluster on a 0.05 significance level according to Pearson's Chi Square test.

[a] three categories pooled to perform Pearson's Chi Square test.

[b] two categories pooled to perform Pearson's Chi Square test.

as type of training or training quality will be of importance (Hoehl, Schleining, Kneifel, Spichtinger, & Astley, 2009).

At still a lower level of dissimilarity, cluster 2A and 2B could be further divided in a third level of clusters (Figure 4.1). Cluster 2A consists of cluster 3A (24 companies), cluster 3B (54 companies) and cluster 3C (5 companies); cluster 2B was split up in cluster 3D (13 companies) and 3E (37 companies). Table 6 shows the response pattern of clusters 3A-3E for the different food safety climate indicators. Total food safety climate scores were significantly different ($p < 0.05$) between all clusters except for 3B versus 3C ($p = 1.000$), although a difference can be noticed in the response pattern of 3B and 3C. Cluster 3B has generally a mode of 4, whilst companies in cluster 3C have a more scattered response pattern. However, as ANOVA (and post hoc Bonferroni) are executed on total food safety climate scores, not taking into account response patterns for individual indicators, no significant difference could be proven based on total food safety climate scores.

Obviously, companies in subclusters belonging to 2A perceive the food safety climate to be higher than subclusters of 2B. For 3A the highest food safety climate scores were noticed according to the response pattern (Table 4.6), and as modes were '5: totally agree' for 26 of the 28 indicators . As already mentioned, 3B and 3C are at a similar level of food safety climate based on total food safety climate scores, with for cluster 3B a mode of 4 for all indicators except indicator E3 and for cluster 3C a more scattered response pattern. Cluster 3D and 3E are at a lower food safety climate level, with cluster 3D having modes quite often equal to '2: Disagree' or '3: Not agree, not disagree'. Pearson's Chi Square test revealed that only 'frequency of food safety training' was significantly correlated to 'cluster' ($p = 0.045$). The cluster with the highest perceived food safety climate, cluster 3A, consisted mainly (62.5%) out of companies providing more than 1 food safety training per year, whilst in the cluster with the lowest perceived food safety climate, cluster 3D, 84.6% of the companies provide 1 or less than 1 training per year. Also for cluster 3E (cluster with the second lowest perceived food safety climate), the percentage of companies with ≤ 1 training per year was quite high (67.6%). No statistical association could be proven with other organizational characteristics, i.e. (inter)national company with multiple sites, multiple sites in Belgium, company size, sector, quality department present, size of quality team, time spent on quality control, certification and budget available for maintaining the FSMS ($p > 0.05$).

As dissimilarity levels were getting too low (distances in dendrogram (Figure 4.1) too small), no additional level of cluster was explored, as this would not give relevant/significant results. Moreover, the third level of clusters (3A-3E) could be considered less relevant, as rescaled distances appear to be lower than those reported in other research (e.g. Luning et al. (2015)).

Table 4.6: Modes of the responses (on a five-point Likert answer scale : 1-> 5: totally disagree, disagree, neutral, agree, totally agree) for each of the 28 indicators of the food safety climate assessment tool for all companies in clusters 3A, 3B, 3C, 3D and 3E.

		CLUSTER 2A			CLUSTER 2B	
		Cluster 3A n=24	Cluster 3B n=54	Cluster 3C n=5	Cluster 3D n=13	Cluster 3E n=37
Leadership[1,2]	**L1**	5	4	5	3/5	4
	L2	5	4	4	4	4
	L3	5	4	**3**	2	**3**
	L4	5	4	4	2	4
	L5	5	4	4	**3**	4
	L6	5	4	4/5	2/3	4
Communica -tion[1,2,3]	**C1**	5	4	5	4	4
	C2	5	4	3/5	3	4
	C3	5	4	4	4	4
	C4	5	4	2/3	2	4
	C5	5	4	3/4	**3**	4
Commitment[1]	**E1**	5	4	5	2	4
	E2	5	4	4/5	**3**	**3**
	E3	4	**3**	2	2	**3**
	E4	5	4	4	**3**	4
	E5	5	4	4	2	3/4
	E6	5	4	4	2	**3**
Resources[1,4,5]	**M1**	4/5	4	4/5	2/3/4	**3**
	M2	5	4	3/5	4	4
	M3	5	4	4/5	**3**	4
	M4	5	4	5	4	4
	M5	5	4	5	4	4
	M6	5	4	5	4	4
Risk awareness[1]	**R1**	5	4	5	4	4
	R2	5	4	4	4	4
	R3	5	4	4	**3**	**3**
	R4	5	4	4	2	4
	R5	5	4	3	**3**	**3**

[1,2,3,4,5,6]: Bonferroni post-hoc shows significant difference for all combinations except: [1] : 3C vs 3B; [2]: 3C vs 3E; [3]: 3C vs 3D; [4] : 3C vs 3A; [5] : 3D vs 3E
For total food safety climate scores: $p < 0.05$, except for 3B vs 3C

4.3.3 Exploratory factor analysis

The underlying factor structure measured through the 28 indicators of the food safety climate tool, as developed in chapter 2, was subjected to exploratory factor analysis. Prior to performing factor analysis, the suitability of our data was assessed using criteria as defined by Tabachnik and Fidell (2013). The Kaiser-Meyer-Olkin (KMO) value was 0.93, which exceeds the required value of 0.60. Also Bartlett's Test of Sphericity was highly significant ($p < 0.001$).

The exploratory factor analysis extracted four factors with eigenvalues exceeding 1. Eigenvalues were 14.62 (factor 1), 1.74 (factor 2), 1.22 (factor 3) and 1.02 (factor 4), with factor 1 explaining 50.9% of variance in the data, factor 2 explaining 4.80%, factor 3 2.97% and factor 4 explaining 2.28% of variance, resulting in a total explained variance of 60.95%. Similar conclusions could be drawn from the scree plot. This explained variance is less than the '75% or more' recommended by Stevens (1996). However, Henson and Roberts (2006) question whether this is a reasonable expectation for research in psychology and social sciences. Hair, Black, Babin, and Anderson (2010) consider 60% in social sciences research as satisfactory. For example, Jespersen, MacLaurin, et al. (2017) reported an explained variance of 61.83% for the factor analysis on their social desirability scale, which is similar to the results in the current study.

Table 4.7 gives the pattern matrix with oblimin rotation and Kaiser Normalization. Factor loadings below 0.3 are suppressed, as association with the given factor would be too weak for lower factor loadings. Overall, Table 4.7 shows that factor 1 is mainly dealing with 'leadership related' indicators, factor 2 with 'resources related' indicators, factor 3 with 'communication related' indicators and factor 4 is less consistent but appears to be a mix of mainly 'risk awareness related' indicators and some 'commitment related' indicators (See Appendix 4.A for complete survey and overview of all indicators).

Moreover, Table 4.7 shows that indicators dealing with component leadership (L1-L6) are all loading on factor 1, except for L3 ('In my organization, the leaders are able to motivate their employees to work in a hygienic and food safe way'), which is loading on factor 4. Content wise and in in line with the other indicators loading on factor 4, this result suggests that leaders might motivate employees by increasing their risk awareness. All indicators dealing with communication (C1-C5) are loading on factor 3, except for C4 ('In my organization, the importance of hygiene and food safety is permanently present by means of, for example, posters, signs and/or icons related to hygiene and food safety'), as factor loadings are below 0.3 for all factors. For C1 and C2, a cross-loading on respectively factor 1 and factor 4, can be noticed, however, both loadings on factor 3 are still higher. Every indicator dealing with component resources (M1-M6) is loading on factor 2. M6 ('In my organization, good procedures and instructions concerning hygiene and food safety are in place') also shows a lower cross-loading on factor 3, which can be explained by the fact that procedures and instructions can only be effective if communicated clearly to all relevant staff. Indicators R1-R5 (component risk awareness) and E1-E6 (component commitment) are more spread over all 4 factors. Additionally, indicator E3 'In my organization, working in a hygienic and food safe way is recognized and rewarded' does not load significantly on any of the factors.

Table 4.7: Pattern matrix obtained through exploratory factor analysis on 28 indicators of food safety climate with oblimin rotation and Kaiser Normalization. (Factor loadings below 0.3 are suppressed). According to De Boeck et al. (2015), 6 indicators (L1-L6) belong to component 'Leadership', 5 indicators (C1-C5) to component 'Communication', 6 indicators (E1-E6) to component 'Commitment', 6 indicators (M1-M6) to component 'Resources' and 5 indicators (R1-R5) to component 'Risk awareness'.

Indicator	Factor			
	1	2	3	4
L1	0.846			
E1	0.767			
L2	0.763			
L6	0.747			
L5	0.562			
R4	0.487			-0.355
E5	0.451			
E4	0.413	0.327		
L4	0.389			
E3				
M2		0.805		
M3		0.651		
M1		0.642		
M6		0.526	0.329	
M4		0.500		
M5		0.360		
C5			0.607	
C2			0.426	-0.302
R1		0.356	0.401	
C1	0.313		0.352	
C3			0.348	
C4				
E6				-0.778
R3				-0.732
E2				-0.729
R5				-0.683
L3				-0.468
R2				-0.352

Further interesting findings relate to the correlations between the factors. Correlations among the four extracted factors were all statistically significant ($p < 0.01$) and ranged from -0.68 to 0.45, providing evidence that factors are indeed correlated.

4.4 Discussion

The overall perceived status of the food safety climate in the responding Belgian food processing companies can be considered good, as, overall, 50.5% of all responding companies agreed and 24.7% totally agreed with the statements/indicators of the food safety climate assessment tool. However, it should be noted that, although the survey is expected to have reached most of the Belgian food processing companies (e.g. through collaboration with industry association, contacting companies directly and also publication in a popular journal), companies choosing to participate can be considered to be already food safety oriented and pro-actively interested in improving food safety management in the organization. This bias is actually common in this kind of research (e.g. study of Luning et al. (2015) with FSMS diagnostic instrument in animal based food sector and Jacxsens, et al. (2015) in another quantitative study in food industry in Belgium) and should be kept in mind for the interpretation, as this is a convenience sample, not representing the whole Belgian food industry.

The fact that companies with multiple sites in Belgium perceive the food safety climate to be better than one-site companies is especially expressed in a significant difference in components: leadership, communication and commitment. A similar pattern was seen in the study performed in chapter 3 in which affiliated butcher shops (affiliates of one large scale centrally coordinated meat distribution company) were compared with independent farm butcheries, as also here, both communication and leadership were perceived to be better in the affiliated butcher shops. This is remarkable as in both cases, it could be expected to be more difficult to streamline (food safety) communication and get managers and leaders spread over the different sites on the same wavelength (Daft, 2009). However, as already stated in chapter 3, it is also possible that having multiple sites spread over the whole nation requires more structured and formal communication in which food safety policy is more clear and which can be managed by more trained people available in larger firms (with multiple sites) (Luning et al., 2015). This is also confirmed by Griffith et al. (2010b) stating that the method of communication (formal or informal), depends on the structure and size of the company, as small business will choose to informally communicate operational knowledge and working practices to employees, whilst larger food companies will provide formal training to perform their tasks. Yiannas (2009) does not focus on formal versus informal, but stresses the importance of using multiple mediums to communicate the organization's food safety information, as this demonstrates that food safety is an important part of the organization's culture. Still, as stated by Griffith et al. (2010b), it could be expected that larger multiple site companies need more formalization, e.g. formal procedures, documentation systems and formal meetings, to clarify and align crucial safety tasks and to support decision-making in their FSMS activities (Luning et al., 2015). Although food safety climate was perceived significantly better in companies with multiple sites in Belgium (compared to one-site companies) ($p = 0.015$), no significant difference in food safety climate scores could be proven related to whether or not companies are 'part of an (inter)national companies with multiple sites' ($p = 0.167$). This could suggest that for companies with sites spread outside Belgium, structured communication and food safety policy might not be sufficient to overcome e.g. language- and/or national culture barriers (Nyarugwe et al., 2016).

The most determining organizational characteristic in the current study is 'frequency of food safety training', as highly significant differences in total food safety climate scores and component scores could be found for this quality related organizational characteristic. The importance of training frequency could also be proven from the cluster analysis, as training frequency was significantly related to which cluster companies belong to and as the major part of companies in lower scoring clusters: 1B (vs. 1A), 2B (vs.2B) and 3D; 3E (vs. 3A; 3B; 3C) are providing 1 training session per year or less. Training frequency is actually also assessed by indicator M5 in the food safety climate tool. Pearson's Chi Square test showed a significant correlation between indicator M5 and 'training frequency' ($p = 0.048$). However, indicator M5 'In my organization, sufficient education and training related to hygiene and food safety is given' is assessing whether the respondent perceives the training frequency to be sufficient, whilst training frequency as an organizational characteristic gives a more objective measurement. The importance of training for food safety culture/climate was already pointed out by several authors (e.g. Nyarugwe et al. (2016); Taylor (2011); Yiannas (2009)). However, Yiannas (2009), although confirming that training is critical, points out that training in itself will not change behavior and that even trained employees, fail to execute certain tasks according to what they have been taught. For instance, Seaman and Eves (2010) stress the importance of managerial support and reinforcement in the workplace for training to be effective. In case of no support after training, food handlers are likely to forget information and perceive the food safety training, and food safety as such, as not being valued in the organization (Worsfold & Griffith, 2010). It might be that the positive effect of providing regular (re)training (according to the current survey: 'more than 1 training/year') on the food safety climate, reflects that food safety is valued by the management in the organization and, as such, employees perceive food safety as more important.

The ideal frequency of training is rather difficult to determine. EU legislation (EC., 2004b) only states that "food handlers are supervised and instructed and/or trained in food hygiene matters commensurate with their work activity". Of course, in case of employees responsible for food safety management and hazard analysis, adequate relevant training should be foreseen. It is also prescribed that for certain sectors requirements set in national law must be followed. For example, in the Belgian self-checking guide for butcheries (FASFC, 2015b) it is prescribed that every butcher should have a license proving his professional competence and should be continuously retrained through the sector association. However, frequency of training for employees is not mentioned. Also the recent Commission Notice on the implementation of FSMSs (EU_Commission, 2016) mentions that training frequency should be determined according to 'the need of the establishment and demonstrated skills'. In the study of Worsfold and Griffith (2010) a frequency of at least every three years is recommended and Yiannas (2009) states that both basic food safety and hygiene information (food safety education) and on the job training should be included.

Interestingly, certification showed no significant correlation with food safety climate scores, which could seem unexpected. However, as pointed out by e.g. Powell et al. (2011) many foodborne outbreaks have been linked to food companies already having some form of certification, which means that a third party audit was performed, after which the FSMS was considered compliant with the applied standard. Powell et al. (2013) mentions several limitations of third party audits, e.g. the fact that these are a snapshot in time and justified certification is highly depending on auditor competence and the effectiveness of the audit tool. The author argues that the effectiveness of an audit is also highly related to the motivation behind the audit and brings up the importance of food safety culture in this matter. Companies with a strong food safety culture will choose to perform an audit (internal or third party), because they value food safety and strive for improvement of their food safety related operations, and not just because of customer demand or legal requirement, suggesting that certification is not enough to guarantee food safety.

Based on our data, no significant relation could be proven between food safety climate and sector (e.g. foods of animal origin, foods of non-animal origin, mixed foods). However, this does not mean that sector is irrelevant in this matter, as Nyarugwe et al. (2016) consider sector values and customer/market demands as external drivers influencing an organization's food safety culture. Luning and Marcelis (2007) stress that organizational characteristics, such as chain characteristics which can be different among sectors, determine the variability and unpredictability in decision-making when executing safety tasks.

Also for different company sizes, no significant difference in food safety climate scores was found, suggesting that both small and large companies can manage to have a good food safety climate, although large companies will face other types of issues than smaller companies. For example, in smaller companies persons in charge are engaged in multiple simultaneous assignments and the lack of profound knowledge or technically qualified personnel may put a challenge to manage food safety (Conter et al., 2007). On the other hand, in large scale companies the management is often more delocated from the people on the workfloor, making efficient and quick communication of food safety information more difficult, as already pointed out above and in chapter 3 in the butcheries.

Difference in yearly budget for maintaining the FSMS appeared to be linked to significant differences in food safety climate, only in comparing cluster 2A with 2B ($p = 0.045$). However, it would not be just to state that a higher budget is related to a higher level of food safety climate, as several respondents expressed difficulty in responding to this question. It is difficult to define exactly which costs should be taken into account as many direct and indirect costs are contributing to maintenance of the FSMS. Zugarramurdi, Parin, Gadaleta, and Lupin (2007) define two types of controllable costs of quality: on the one hand, there are prevention costs, consisting of costs related to design, development and implementation of a quality assurance plan, quality training programs for suppliers and production personnel, hygiene and sanitation of the plant, preventive maintenance and additional supervision. On the other hand, the authors consider appraisal costs, comprising costs related to receipt and control of incoming material, sampling and laboratory analysis and in-process inspection. Many of these costs can contribute both directly and indirectly to maintaining the FSMS, and also relations between these different types of costs might exist, complicating an exact estimation of FSMS related costs for food processing companies.

Exploratory factor analysis revealed the existence of four underlying factors in the 28 indicators of the food safety climate self-assessment tool. The remarkable result that factor 1 explains most variance (50.9%) in the data set and refers content wise to the 'leadership related factor', probably reflects that leadership issues are very salient in the mindset and perceptions of our respondents (i.e. quality managers and plant managers) when questioned about the food safety climate in their food processing organization.

The importance of leadership in cultivating a strong and positive food safety climate is also widely discussed in literature (e.g. Nyarugwe et al. (2016); Griffith et al. (2010a)). An organization needs good leaders to be more successful (Tsai, 2011). Good leaders make sure employees know where the organization is heading and why, which facilitates higher engagement and motivation among employees (Griffith et al., 2010a). In his book 'Organizational culture and leadership', Schein (2017) states the following: "leadership is involved in the creation of the culture and at every stage of the organization's growth and maturity" (p.15). The author also puts leadership as the key to learning by reinforcing or 'disconfirming' behavior. This also brings us to the discussion of management versus leadership. Although often used interchangeably these are two distinct but complementary concepts (Griffith et al., 2010a). Maccoby (2000) puts it as follows: "Management is a *function* that must be exercised in any business, whereas leadership is a *relationship* between leader and led that can energize an organization" (p. 57). A similar definition is given by Griffith et al. (2010a) stating that leadership is about influencing people, whereas management is about control and creating predictable results. In 2015, ISO standards saw a fundamental upgrade with a common element in all of the 2015 editions, a renewed focus on leadership, making also a clear distinction between leadership and management (ISO, 2015a). In ISO 9000:2015 top management is defined as "a person or group of people who directs and controls an organization at the highest level", whilst following statement is made about leadership: "leaders at all levels establish unity of purpose and direction and create conditions in which people are engaged in achieving the organization's quality objectives "(ISO, 2015a). This means managers can be leaders, but not necessarily are. This is also reflected in the requirements defined in ISO 9001:2015 , e.g. stating that top management should demonstrate leadership and commitment (ISO, 2015b).

Considering the pattern matrix resulting from the factor analysis (Table 4.7), generally, it could be stated that most indicators are loading on their expected factors. Still, some remarks should be taken into account. As indicators C4 ('In my organization, the importance of hygiene and food safety is permanently present by means of, for example, posters, signs and/or icons related to hygiene and food safety') and E3 ('In my organization, working in a hygienic and food safe way is recognized and rewarded') are not significantly loading on any of the factors, these indicators could be considered for deletion. However, this does not mean that both indicators are irrelevant, as they were all deemed relevant by expert validation performed in chapter 2. This result only shows that, statistically, there is no direct link with any of the overarching factors extracted from the exploratory factor analysis. Alternatively, It might be that the wording of some indicators is interpreted by our respondents differently compared to other types of participants (e.g. operators). Indeed, in the pilot study in chapter 2 differences are reported in scores on particular food safety climate indicators between management and staff of a large scale meat distribution company. For indicator E3 ('In my organization, working in a hygienic and food safe way is recognized and rewarded') the link with 'commitment' may be less clear. Still, several authors (e.g. Roth and Clifton (2004); Griffith et al. (2010a)) already stated that praise and recognition can motivate employees to engage and to be committed to e.g. food safety. A similar explanation can be put forward in case of indicator C4 ('In my organization, the importance of hygiene and food safety is permanently present by means of, for example, posters, signs and/or icons related to hygiene and food safety'). It might be that this indicator is not consistent with the other communication indicators, as indicator C4 is more dealing with non-verbal/non-oral means of communication, whilst, although not literally mentioned, respondents could consider C1, C2, C3 and C5 rather dealing with verbal communication. However, this non-verbal/oral way of communication is also important, as Yiannas (2009) pointed out that using multiple (also non-verbal) mediums should be used for successful transfer of food safety information.

The fact that indicators R1-R5 (component risk awareness) and E1-E6 (component commitment) are mixed in a single factor and are not distinguished by our respondents could be due to the fact that commitment and risk awareness are the least tangible dimensions and least delimited/defined. Also in the study of Jespersen and Wallace (2017) it is questioned whether their dimension 'risks and hazards' should be considered as a stand-alone dimension (Jespersen & Wallace, 2017).

However, the fact that indicators E1,E4, E5 and R4, are loading strongly on factor 1 (the 'leadership related' factor), can be explained by the fact that these indicators are all dealing with perceptions of 'leaders': 'In my organization, the leaders clearly consider hygiene and food safety to be of great importance'(E1); 'In my organization, the leaders set a good example concerning hygiene and food safety' (E4); 'In my organization, the leaders act quickly to correct problems/issues that affect hygiene and food safety' (E5) and 'In my organization, the leaders have a realistic picture of the potential problems and risks related to hygiene and food safety'(R4). Deletion of certain indicators of food safety climate was discussed based on the factor analysis results. However, with the objective of the indicators of the food safety climate tool in mind, i.e. assessing relevant issues/topics contributing/shaping an organization's food safety climate and taking into account the limited sample size on which results are based, the authors concluded not to delete any indicators. Shifting indicators to other components was also discussed. But it should be considered that it is maybe not possible to create completely distinct factors/components, as suggested by the correlation matrix and as several examples exist in literature, providing evidence that factors are related to one another. For example, McLellan (1994) provides evidence for the correlation between leadership and communication. Frewer (2004) linked risk awareness to effective risk communication. Griffith et al. (2010a) state that one of the roles of a leader is to provide recognition to employees to increase their commitment to food safety, as such, linking leadership to commitment. Moreover, the results of the factor analysis should be interpreted with caution as these are based on a relatively small sample (136 respondents). Also, all respondents were mainly quality managers or plant managers, which could bias the results as perceptions of front line staff/operators are not taken into account. Also a rewording and a more target group specific formulation or tailoring of some indicators, instead of the deletion or shifting of indicators, might contribute to the valid measurement of perceptions regarding the food safety climate. Another potential bias in our food safety climate assessment is the fact that all 28 indicators are considered equally important in the assessment. The use of weighing factors for the different indicators was not investigated and could be interesting to explore in further research. In conclusion, the factor structure of the food safety climate self-assessment tool needs to be futher explored, as the sample size is rather small and only managers were included in the sample.

Important to take into account in interpretation of the results, is the fact that through the food safety climate self-assessment tool, ‘perceptions’ are measured. Consequently, as no triangulation was performed, this could result in an important bias.

4.5 Conclusion

Based on the perceptions of 136 quality managers/plant managers/production managers, food safety climate can be considered good in the responding Belgian food processing companies, as, overall, 50.5% of all responding companies agreed and 24.7% totally agreed with the statements/indicators of the food safety climate assessment tool. Having multiple sites in Belgium does not seem to pose difficulties in streamlining communication and getting people on the same wavelength, as most multiple site companies are more organized and prepared for structured and clear information transfer. Respondents working in food companies providing more than one training session per year appeared to perceive the food safety climate in their company significantly better than respondents from companies providing less training. For food safety training to be effective, employees must perceive that food safety and food safety training are valued in the organization, which might be achieved by making resources available allowing regular training and retraining, instead of reflecting that training is merely a formal administrational issue. Based on the data, no significant correlation could be proven between food safety climate scores and whether or not companies were certified for multiple standards. This suggests that third party certification may influence FSMS design and implementation but not the associated food safety climate. However, the underlying motivation for obtaining a third party certification may play a role in the perception of food safety climate in the organization. Also the correlation with sector and company size was not significant.

Exploratory factor analysis revealed the existence of four underlying factors in the assessment of companies’ food safety climate: factor 1 is mainly dealing with ‘leadership related’ indicators, factor 2 with ‘resources related’ indicators, factor 3 with ‘communication related’ indicators and factor 4 is a mix of mainly ‘risk awareness related’ indicators and some ‘commitment related’ indicators. Factor 1, i.e. the ‘leadership related factor’, explained most variance in our data set, suggesting the importance of leadership in cultivating a strong and positive food safety climate. Indeed, leadership style has been linked to attitudes and intentions of employees to follow safe food handling practices (Lee et al., 2013), which is also confirmed in an occupational health and safety context (Mortier, Vlerick, & Clays, 2016).

The five dimensions (leadership, communication, commitment, resources and risk awareness) as defined in the food safety climate assessment tool (chapter 2), were only partly reflected in the extracted factor solution. Results suggest that for some organizational stakeholders food safety climate might be represented through less than five dimensions. Still, as these factors are correlated, it might be that defining completely distinct components/factors is rather difficult. Further research on the factorial validity of our tool is recommended.

In interpreting the results of the current study, the fact that results are based on perceptions should be kept in mind, suggesting that conclusions are related to attitudes and not actual behavior and that instead of leadership as such, ‘perceived’ leadership is discussed, as no objective measurements of e.g. leadership skills were executed.

Chapter 5

Method triangulation to assess different aspects of food safety culture within food service operations

Abstract

As in chapter 4 an important bias could have been induced by the fact that conclusions could only be based on ‘perceptions’ of employees, in this chapter a methodological triangulation was performed. The advantages and added value of applying method triangulation to gain a more comprehensive evaluation of food safety culture were illustrated by means of a case study. Three methods are applied assessing the food safety culture in food service operations of a Flemish University, consisting of 9 university restaurants and 7 university cafeterias spread over different locations in the city of Ghent, but centrally managed. Each method sheds light on one of the aspects of ‘food safety culture’ as defined in the food safety culture conceptual model. Two system and product related methods, being internal audits and verification of monitoring data of Critical Control Points (CCPs) as part of the HACCP system, both assessing the performance of the FSMS and as such belonging to the techno-managerial route, will be compared with a people related method using the food safety climate self-assessment tool, which is belonging to the human route. By triangulation of these three methods different aspects of the food safety culture at the different locations could be investigated, illustrating how single-method derived results could lead to wrong conclusions. Moreover, by combining the assessment methods case by case, locations in which the hazard of optimistic bias and complacency might exist, can be identified. As such, more tailored and location specific strategies for improvement can be put in place.

5.1 Introduction

Eating out of home, at food service operations such as cafeterias, canteens, fast food outlets and restaurants has become evident for the 21th century consumer (Vandevijvere, Lachat, Kolsteren, & Van Oyen, 2009). Indeed, according to the study of Vandevijvere et al. (2009) 35% of the Belgian population can be considered as 'substantial out-of-home eaters', as they consume on average more than 25% of their daily energy outside their home. Moreover, Michaelis and Lorek (2004) state that out-of-home consumption is significantly growing in Europe, with in 2002, a proportion of 24.4% of food intake consumed out of home accounting for 25% of total household food expenditures. As already stated in section 1.2, of the 351 foodborne outbreaks reported in Belgium in 2015, main place of exposure (76.6%) were restaurants and take away fast food services (WIV-ISP, 2016). For Europe, main place of exposure of the 409 strong-evidence outbreaks in 2015 was the household (45.7%). Still, canteens and other settings where food was prepared and/or served by catering services (23.7%) and restaurants, pubs, street vendors and take-away establishments (19.6%) also accounted for an important proportion of strong evidence outbreaks (EFSA_and_ECDC, 2016).

Food handlers in these type of food service operations have to deal with various types of raw/at-risk materials and have to serve and prepare a wide variety of final products. Ensuring correct hygiene and food safety practices can be quite challenging in this sector (Lahou, 2016). Moreover, high staff turnover has been reported as a major problem in these food service operations, hindering the continuous sustainment of knowledge in these food service operations (Eves & Dervisi, 2005). This indicates the importance of having a well-functioning FSMS, as the performance of the FSMS in catering activities is largely affecting the quality and safety of the offered food products, which was demonstrated; for example, in the study of Lahou et al. (2012) in Flemish food service operations and by Luning, Chinchilla, Jacxsens, Kirezieva, and Rovira (2013) in Spanish food service establishments. As stated in section 1.1.1, EU Regulation 852/2004 encourages the use of guides to good practice, covering PRPs, HACCP and other sector specific requirements. In Belgium, these national agreed guides (approved by the Belgian FASFC) are used as auditing reference to validate the organization's FSMS. For example, the self-checking guide for the catering and care facilities sector provides guidance for developing and maintaining a FSMS based on HACCP principles and good practices (FASFC, 2015a). This guide, is among others, applicable to kitchens and refectories of companies, schools, hospitals, prisons and banquet halls. In these types of establishments generally ready-to-cook or ready-to-eat meal components are purchased, which are immediately ready for consumption (served chilled) or which still have to be (re)heated before serving. Applying correct temperatures, both during chilled storage and heat treatment, is of major importance to guarantee food safety of food products in these food service establishments. For example, the self-checking guide prescribes a maximum temperature for products in the cold chain, of 7°C (FASFC, 2015a). Minimum temperature for regeneration/heat treatment is 75°C, to make sure that during serving to consumers temperatures are still above 60°C. The monitoring of these temperatures is a key quality control activity of the FSMS in food service operations.

Lahou (2016) and Ropkins and Beck (2000) recommend periodic verification of the HACCP plan and FSMS as a whole, as this has been proven to be more effective than only controlling final products by e.g. sampling and microbiological analysis. Several techniques used for the verification of the functioning of a food service operation are reported in literature (see also Table 1.1). For example, in the study of Garayoa et al. (2014) external audits and microbiological analysis were performed in Spanish catering companies to verify their HACCP plan. Osimani et al. (2013a) used internal audits in Italian university canteens. Additionally, as indicated in Table 1.1, several researchers propose diagnostic tools using performance indicators to assess the performance of the FSMS. For example, Luning et al. (2013) verified performance of the FSMS in Spanish food service establishments by means of a diagnostic instrument. The methods applied in the three cited studies can be categorized as 'System and product related performance measurements' (see section 1.1.3). However, 'People related performance measurements' (see section 1.1.3) for assessing food safety (and hygiene) performance (broader than FSMS performance) might be equally important in these establishments. Indeed, the importance of food handler (mal)practices in this matter, is already widely discussed in literature: e.g. Baert et al. (2009) reported that food handlers were epidemiologically linked to 80% of the Norovirus outbreaks reported in Belgium. Also Table 1.3 provides evidence of the link between food handler errors and food safety issues, especially in these food service operations. In total, of the 35 (Table 1.3a and b) identified scientific publications between 2009 and 2017 dealing with food safety problems originating from food handler practices/behavior for microbiological hazards (both European and non-European publications), 26 of these 35 publications were performed in the food service sector (e.g. restaurants and catering).

Furthermore, Jespersen and Wallace (2017) pointed out the importance of triangulation of research methods, as strengths in one method or technique can compensate weaknesses in other methods (Carugi, 2016; Kopinak, 1999). Kopinak (1999) defines method triangulation as "a means to gather information pertaining to the same phenomenon through more than one method, primarily to determine if there is a convergence and hence, increased validity in the findings" (Kopinak (1999), p 171).

As in the previous chapter (chapter 4), one of the main research limitations, was the fact that results and conclusion were derived from a single method (self-reported survey-ratings), the goal in this chapter is to perform a method triangulation which might allow a more comprehensive evaluation of food safety culture in an organization (Jespersen & Wallace, 2017). Making reference to the food safety culture conceptual model presented in section 1.4.2 (Figure 1.3), food safety culture is considered as the interaction and result of both techno-managerial and human aspects or routes.

Three methods will be applied assessing different aspects of the food safety culture in food service operations of a Flemish University, consisting of 9 university restaurants and 7 university cafeterias spread over different locations in the city of Ghent but centrally managed. Each method will shed light on one of the aspects of 'food safety culture' as defined in section 1.4.2. Two system and product related methods being internal audits and verification of registration data of Critical Control Points in the frame of daily monitoring of the HACCP system, both assessing the performance of the FSMS and as such belonging to the techno-managerial route, will be compared with a people related method using the food safety climate self-assessment tool, which is belonging to the human route. By triangulation of these three methods different aspects of the food safety culture can be investigated in these university food service operations as case study.

5.2 Material and methods

5.2.1 Characterization of the food service operation

The university food service operations in this case study consisted of 9 university restaurants (coded as restaurant A till I) and 7 university cafeterias (coded as cafeteria A till G) spread over different locations in Ghent, Belgium. A central management is present and the FSMS based on PRPs and HACCP is elaborated by the central management and communicated via procedures, instructions, registration forms, e-mail communications, face-to-face communication and training activities over the past years (since 2002 formal start-off of current FSMS). In restaurants the number of employees varies from 5 to 20. In cafeterias only 2 to 6 persons are employed at each location. In order to anticipate in case of busy periods or sickness, 7 extra employees are employed (called 'butterflies'), which are not fixed at a location but are deployed at locations where they are necessary. The restaurants offer daily hot meals, soups, sandwiches and salads, whereas the cafeterias do not offer hot meals, but sandwiches and soups and at some locations also snacks (e.g. sausage rolls) can be obtained. All ingredients are purchased centrally as ready-to-(re)heat meal components by the Meal Provision Department of the university. Consequently, ingredients are distributed at fixed days to the different locations, temperature upon arrival and shelf life are controlled and products are appropriately stored (cold, frozen or ambient temperature storage) until processing. Each restaurant has its own regeneration kitchen where undercooked frozen, prepared frozen (cook and freeze) or chilled (cook and chill) meal components are (re)heated to complete the cooking process. The heated meal components are then stored in a counter and kept warm through bain-maries, so temperatures above 65°C can be maintained. From these bain-maries, portions are served by the personnel to the customer (mainly university students, academic staff and guests). Chilled meal/sandwich components are kept in storage rooms or closed refrigerators as long as possible. An appropriate (not too big, because temperature could increase) portion is kept in a cooled counter from which sandwiches are prepared by the personnel at request of the customer. Some locations also offer salad bars, where chilled meal components are kept in a cooled counter, and are offered to customers through self-service. Soups are kept warm in closed bain-maries and are also offered through self-service. Snacks (e.g. sausage rolls) are heated in a microwave by the personnel on request of the customers.

In 2015, the total number of individual payments over the different locations was 1 019 109 for the whole year, of which 54.38% hot meals and 45.62% sandwiches. This means that on average, over all locations approximately 2 293 hot meals and 1 934 sandwiches were sold every working day (no weekends and holidays) in 2015.

5.2.2 System and product related verification methods

The FSMS is elaborated centrally for all restaurants and cafeterias and is based on the self-checking guide for the catering and care facilities sector in Belgium (FASFC, 2015a). The FSMS comprises a HACCP system based on 14 PRPs (e.g. cleaning and disinfection), 5 control points (CPs) (e.g. not leaving refrigerated meal components at ambient temperatures for too long) and 8 critical control points (CCPs). CCPs are mainly dealing with applying correct temperatures during storage (cold storage of ingredients at 4 or 7°C), transport (between different locations at 4 or 7°C), regeneration (heating till a core product temperature of 75°), frying (maximum frying temperature of 175°C) and serving (respecting cold or hot temperature of components).

The first verification method performed in this study, is a verification of monitoring data of three selected CCPs. Focus was on CCP5, CCP6 and CCP7, as compliance with and correct registration of these CCPs are most depending on behavior and attitudes of the food service operators. CCP5 is dealing with core temperatures of products immediately after regeneration (reheating). As stated in the self-checking guide core temperatures should exceed 75°C (FASFC, 2015a). An exception was made for certain products which are either precooked (fish fillets belonging to defined fish species) or raw non-comminuted meat such as or beef steaks, where lower regeneration temperatures (50 to 60°C depending on the product) are preferred because of sensorial reasons and microbial contamination being already low or located on the outside surface of the product. These products are clearly defined on an exception list for regeneration which is available to the employees (see Appendix 5.G). CCP6 is dealing with checks of temperatures to be read from displays of frying equipment and bain-maries. For the latter a minimum limit of 80°C is set, whilst the temperatures of the frying oil should not exceed 175°C, as elevated temperatures might enhance formation of acrylamide and free fatty acids (FASFC, 2015a). Finally, CCP7 comprises both minimum core temperatures for heated meal components (65°C for most products) and maximum core temperatures for chilled meal components or products when temporarily stored at the serving counter (4 or 7°C). After regeneration, hot meal components are kept warm in bain-maries, which should guarantee a minimum core temperature of 65°C. Chilled food products, e.g. fresh produce and spreads for salads or sandwiches, are kept at the counter with a maximum allowed core temperature of 7°C. For some high risk products, such as a raw minced meat spread ('américain prepare') and smoked salmon, temperatures should not exceed 4°C. For these CCPs (5, 6 and 7) registrations forms were available for each location, as these temperatures are monitored daily by the food service personnel.

For each location the registered data were inserted in a spreadsheet (Excel 2010), developed by the researchers, for the period March 7, 2016 until November 18, 2016, as for this period original paper version registration documents were available. For CCP5, 22 765 measurements of core temperatures of food products after regeneration were collected as data points. Registered display temperatures of bain-maries and frying equipment were added in separate sheets in Excel. The latter resulted in 3 659 data points for the university restaurants only, as no fried foods are offered in the cafeterias. Bain-maries are available in all restaurants and in cafeteria C, resulting in 8 140 data points. The 24 681 data points for CCP7 were split up in core temperatures measured for heated components (lower limit of 65°C) (10 046 data points for restaurants and 3 171 data points for cafeterias) and temperatures measured for chilled components, which was again split up in 'general chilled components (upper limit of 7°C)' (4 810 data points for restaurants and 3 308 data points for cafeterias) and 'high risk chilled components (upper limit of 4°C)' (smoked salmon and raw meat spread) (1 373 data points for restaurants and 1 972 data points for cafeterias). Furthermore, a distinction was made for CCP7 between measurements at the start of the service and measurements at the end of the service (3 (restaurants) to 6 (cafeterias) hours). By means of the obtained data base, monitoring data for CCP5, CCP6 and CCP7 were investigated as a verification of control activities as a part of the FSMS. Restaurants and cafeterias were compared based on the number of non-conformities, defined as non-compliance with the limits described above. Important to note is that the goal of this chapter was not to verify the validity of the limits applied by the food service operation nor to verify the validity of the HACCP system as a whole. Only non-compliance with the set limits was investigated.

The second system and product related verification method used, were internal audits. Internal audits were executed on every location by the same researcher, accompanied by the central HACCP coordinator of the university's Meal Provision department. The researcher received a certified internal auditor training before starting the audits (based on ISO 9000 principles). Based on the 14 PRPs, 5 CPs and 8 CCPs as described in the HACCP plan, a checklist was developed with 26 audit indicators or checkpoints (see Table 5.1). For each of the audit indicators a score from 0 to 3 could be given by the auditor: 0 indicating that the activity which is described is never correctly executed , 1 indicating that non-conformities were noticed during the audit and there is no follow-up/attention/awareness from the employees concerning this indicator; 2 indicating that non-conformities were noticed during the audit, but employees are aware of the importance/problem and take action; 3 indicating that no problem/non-conformity was noticed during the audit. For each of the 16 locations the scores for the 26 audit indicators could be added up, giving a total audit score for each location with a maximum possible score of 78. Every audit took approximately 1 hour and all audits were performed in the period November 2016 – May 2017.

5.2.3 People related verification method: assessment of food safety climate

Food safety climate in all 16 locations was assessed by means of the food safety climate self-assessment tool. Formulation of the 28 indicators of the tool was slightly adapted based on discussions with the overall responsible and HACCP coordinator of the Meal Provision Department, in order to make sure terminology was clear for all employees. As in many of the indicators 'leader' is mentioned, two versions were made of the survey: one version for the staff members and one version for the location responsible, as for frontline employees 'leader' means the location responsible and for the location responsible this corresponds to the central HACCP coordinator. This was clarified in the survey. For the 28 indicators a five-point Likert answer scale was used (1 → 5: totally disagree → totally agree). Some general questions were added, assessing the type of contract (fixed contract working at fixed location, fixed contract working at different locations ('butterfly'), job student, interim) and job seniority at the Meal Provision Department (less than 1 year, between 1 and 5 years, 5 years and more). All employees of each of the 16 locations were asked to fill out the survey. A paper version was handed over in a closed envelope to all employees in person by the same researcher. First a short explanation was given about the survey, stressing the fact that responses would be used anonymously by the researchers. The closed envelopes could be deposited in a sealed/closed box at each location, which was collected and delivered to the researcher one to two weeks after dissemination of the surveys.

After removal of surveys for which less than half of the indicators were filled out, a total of 92 respondents for the restaurants and 27 respondents for the cafeterias could be used for analysis.

Food safety climate scores as perceived by staff (the employees not including the location responsible) and as perceived by the location responsible were visualized separately through frequency tables. For all data analysis IBM SPSS Statistics 23 (Chicago, Illinois) was used.

5.3 Results

5.3.1 System and product related verification methods

5.3.1.1 Verification of registration data of critical control points

CCP5

For CCP5 which is dealing with registered regeneration temperatures, 22 765 data points were collected. In line with the exception list for regeneration (Appendix 5.G), 2 173 data points were eliminated, as these products were allowed to have lower generation temperatures (e.g. certain fish species). As such, for all remaining data points, registered core temperatures below 75°C were considered as 'non-conformities'. In Figures 5.1A and 5.1B the distributions of the non-conform regeneration temperatures are given for the different restaurants and cafeterias respectively. Percentages are calculated as the number of non-conformities for a specific restaurant/cafeteria over the total number of registrations for CCP5 for that specific restaurant/cafeteria. Cafeteria A, B and C and restaurant B are not displayed in Figure 5.1, as no non-conformities were registered for CCP5. In Appendix 5.A a complete overview of the data processing for CCP5 is given for the different restaurants and cafeterias.

Concerning the registered regeneration temperatures (CCP5) it can be concluded that 2.17% of the registered temperatures (with critical limit of 75°C) over all restaurants were non-conform. In all restaurants non-conformities were registered, except for restaurant B, with a maximum of 5.08% non-conformities for restaurant C. Most non-conformities were still close to 75°C (73-74°C), only for restaurants C and I, where a large number of non-conformities below 68°C were registered (3.1% of the registrations for restaurant I and 5.07% for restaurant C). However, for these two locations 100% (restaurant C) and 95% (restaurant I) of the non –conformities were originating from applying 58°C as a regeneration limit for reheating precooked fish and fish preparations which were not on the exception list for regeneration (Appendix 5.G). Because of confusion about which precooked fish species were allowed or not to be subjected to lower regeneration temperatures (and thus seemingly no good communicaton or understanding of the products on the exception list), employees frequently registered too low regeneration temperatures. The latter especially for fish as some fish species (preparations) are on the exception list (e.g. marinated Atlantic salmon steak) and others are not (e.g. cod crumble). Concerning the cafeterias, non-conformities were registered in 3 of 6 locations. Cafeteria G is not included here, as no regenerated products are offered in this cafeteria. In total 1.88% of registered temperatures over all cafeterias were non-conform. Highest percentage of reported non-conformities (5.57%) was found in cafeteria D.

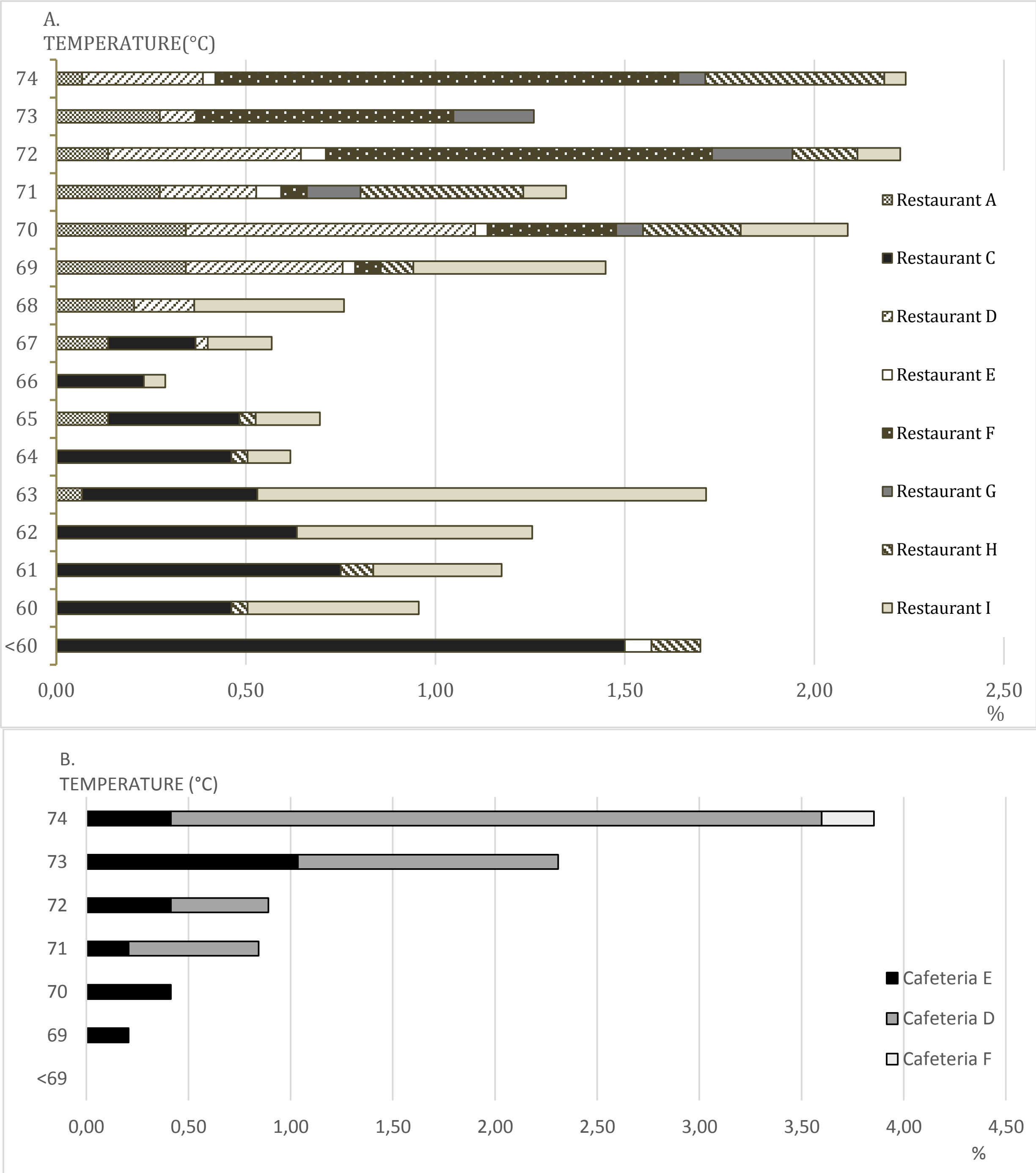


Figure 5.1: Distribution of the non-conform temperatures for CCP5 (minimum limit 75°C) A: Restaurant A till I; B: cafeterias A till F. For each registered temperature percentages are calculated as the number of non-conformities for a specific restaurant/cafeteria over the total number of registrations for CCP5 for that specific restaurant/cafeteria. Only cafeterias and restaurants with reported non-conformities are displayed.

CCP6

A complete overview of the data processing results for CCP6 for all restaurants and cafeteria C (CCP not applicable to other cafeterias) can be found in Appendix 5.B (frying temperatures) and 5.C (bain-maries display temperatures). Figure 5.2 gives the distribution of the non-conform temperatures for CCP6 temperatures bain-maries (<80°C). Percentages are calculated as the number of non-conformities for a specific restaurant/cafeteria over the total number of registrations for CCP6 for that specific restaurant/cafeteria. As formation of acrylamide significantly increases from temperatures above 175°C, EU Regulation 2017/2158 (EC., 2017a) prescribes that frying temperatures should be controlled and are recommended to be below 175°C. The number of exceedances of 175°C as a frying temperature is quite high, with a maximum percentage non conform temperatures in restaurant H (97.69%). However, deviations from this value of 175°C are relatively low, with a maximum temperature of 184°C, which was registered for restaurant D and restaurant E and P_{90} was for all locations below 178°C.

As no non-conform temperatures of the bain-maries were registered for restaurants C, F, I and cafeteria C, these location are not displayed on Figure 5.2. A maximum number of non-conformities could be noticed for restaurant G, where 6.94% of the registered display temperatures were below 80°C. However, also for this CCP, deviations from the value of 80°C were rather small (1 or 2°C too low). Only for restaurant E a larger deviation from 80°C was noticed: 66°C – 79°C. Therefore it can be expected that this will have an effect on the maintenance of (high enough) core temperatures of the (re)heated foods when served in the hot buffets for restaurant E (CCP7).

CCP7

Appendix 5.D gives an overview of data processing results for the cold temperature registrations of smoked salmon and raw meat spread (upper limit of 4°C) measured respectively at beginning and end of the shift (CCP7). Appendix 5.E displays results for chilled components with upper limit of 7°C and Appendix 5.F for temperature measurements in the hot buffets (lower limit of 65°C) (CCP7). For the hot buffets products on the ‘exception list for regeneration’ (Appendix 5.G), for which lower regeneration temperatures than 75°C were allowed, were excluded in the analysis of non-conformities for CCP7 (hot buffets). In cafeterias no non-conform temperatures were registered for hot buffets. From Figure 5.3 it can be concluded that at start of the shift 4 of 9 restaurants registered temperatures below 65° for the hot buffets, which results in 1.10% non-conformities calculated on all registered data for CCP7 hot buffets start of service. At the end of the shift the total percentage of non- conformities decreased to 0.79%. However, 40% of the hot meals were sold out at the end of

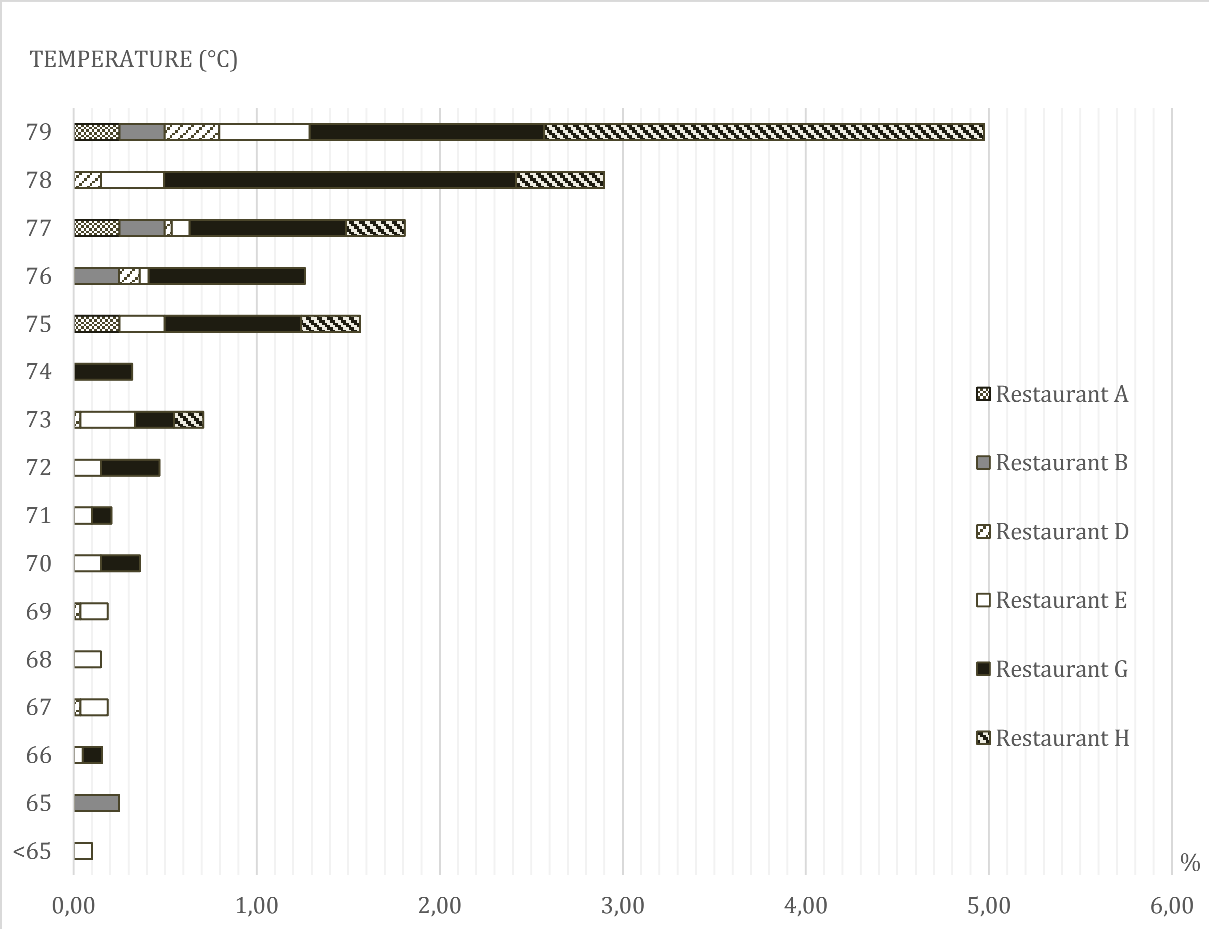


Figure 5.2: Distribution of the reported non-conform temperatures for CCP6 temperatures bain-maries (lower limit 80°C) for Restaurant A till I. For each temperature percentages are calculated as the number of reported non-conformities for a specific restaurant over the total number of registrations for CCP6 (temperatures bains-marie) for that specific restaurant. Only restaurants with reported non-conformities are displayed.

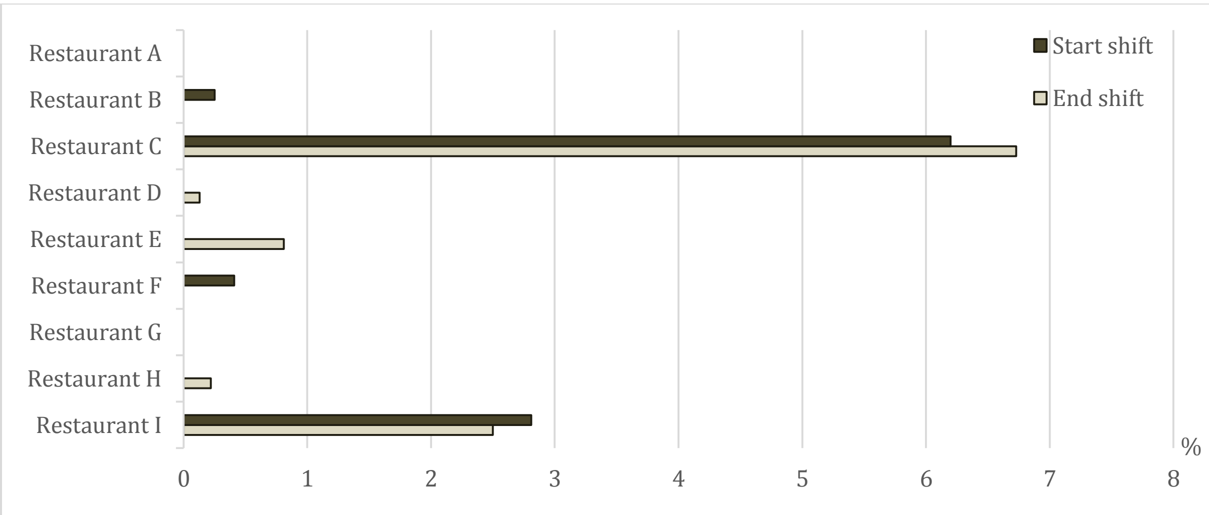


Figure 5.3: Distribution of the reported non-conform temperatures for CCP7 core temperatures hot buffets (lower limit 65°C) for Restaurant A till I. Percentages are calculated as the number of non-conformities at start or end of service for a specific restaurant over the total number of registrations for CCP7 (core temperatures hot buffets) at start or end of the shift for that specific restaurant.

the shift and thus less ‘bain-maries’ needed to be monitored. Most non-conformities, both for start and end of service, were registered in restaurant C and I. This could be due to the fact that these restaurants frequently apply lower regeneration temperatures (58°C instead of 75°C) for fish species which are not on the exception list (CCP5). Consequently, temperatures registered in the hot buffets cannot reach 65°C. The increase in non–conformities between start and end of shift for restaurants D, E and H might be explained by the fact that bain-maries temperatures (CCP6) in these restaurants do not reach 80°C in respectively 0.71%, 2.52% and 3.69% of the registered data (see Appendix 5.C.).

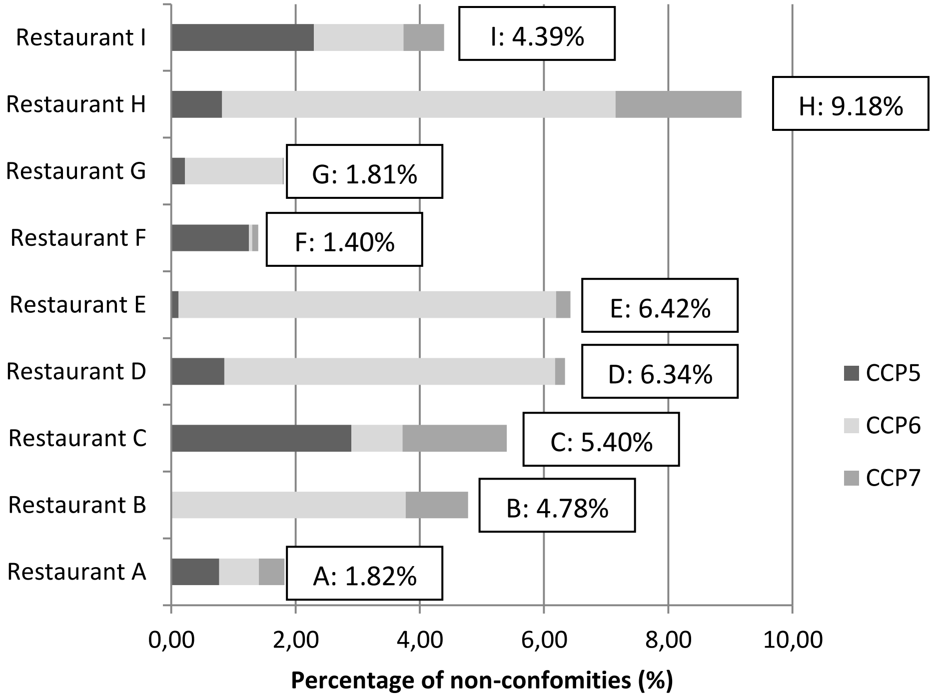
On the contrary, restaurants B, F and I have a higher number of non-conformities at start of the service compared to the end of the service. For the latter 2 locations, no non-conformities are registered for CCP6 (bain-maries), whilst for restaurant B 0.99% of the registered temperatures were below 80°C. However, for this location a P_{50} of 92°C was reported, suggesting that more than half of the temperatures were far above the limit of 80°C, which can result in further heating of products in the hot buffets. For restaurants A and G no non-conformities were registered for CCP7 hot buffets.

For CCP7 for chilled products with upper limit of 7°C only three locations (restaurants and cafeterias) show non-conformities at the start of the shift, with a maximum percentage of non-conformities for restaurant H (1.67%). At the end of the shift, already 6 locations registered temperatures above 7°C. Moreover, 5.33% of products are sold out at the end of the shift. The fact that for restaurant H the P_{75} and P_{90} appeared to be above the limit of 7°C, suggests that the location is not able to get temperatures in cold buffets under control. Among the cafeterias, cafeteria G had clearly more non-conformities than other cafeterias (7.11%).

Looking at the reported non-conform temperatures for CCP 7 (core temperatures smoked salmon and raw meat spread, upper limit 4°C), revealed that the number of non-conformities increases between start and end of the shift in the restaurants. Moreover, in nine of 14 locations the registered temperatures at start of the shift were already above 4°C. In restaurants B, D and E exceedances are quite high (up to 8°C) . However, in cafeterias, no or very few non-conformities (0-0.56%) are registered for this CCP, except for cafeteria G where again the highest percentage of non-conformities was registered (17.39%).

Overview of all three CCPs

As an overview, Figure 5.4 gives the percentage of non-conformities for each location for the three included CCPs in this verification. The percentage is calculated as the number of non-conformities for a specific location for a specific CCP over the total number of registered data for that location (over



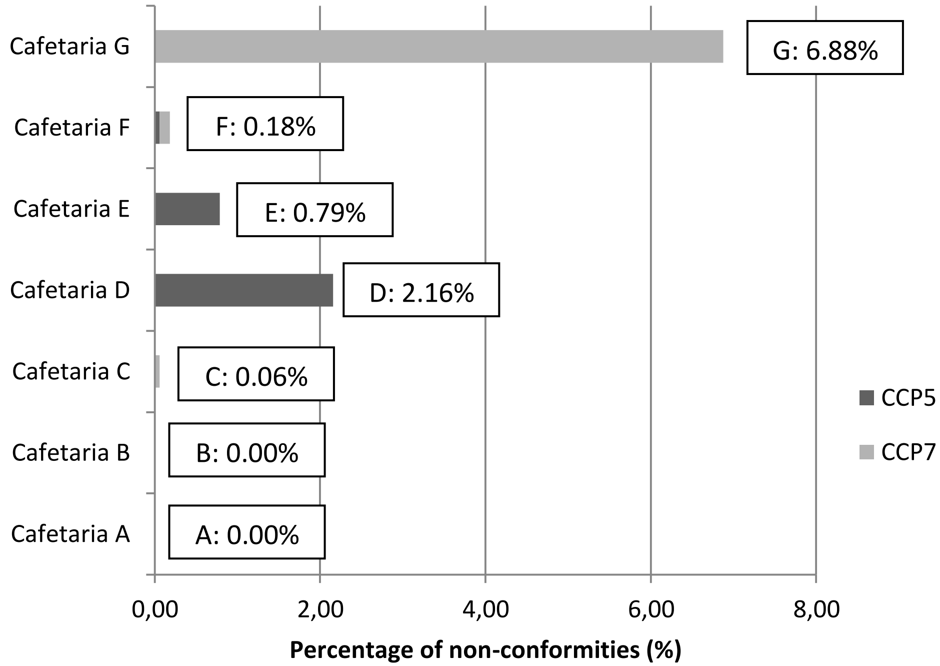


Figure 5.4: Percentage of non-conformities for each restaurant (left) and each cafeteria (right) for the three CCPs included. Percentage is calculated as the number of non-conformities for a specific location for a specific CCP over the total number of registered data for that location (over all CCPs). Total percentage of non-conformities over all CCPs is given in the box for each location.

all three CCPs). For the restaurants it can be stated that restaurants A,F and G have less than 2% non-conformities in total, whilst the other restaurants have more than 4% up to 9.18% for restaurant H. The restaurants with the highest percentage of non-conformities were restaurants D (6.34%), E (6.42%) and H (9.18%). Remarkably, these restaurants are responsible for the highest sales volume of hot meals. Main cause of this high number of non-conformities, which was also the case for restaurant B and G, were temperatures of frying equipment and bain-maries (CCP6). In restaurants A, C, F and I the biggest share of non-conformities was due to CCP5.

Generally, a rather low percentage of non-conformities was reported for cafeterias. Moreover, cafeteria A and B did not report any non-conformity. A maximum number of non-conformities (6.88%) was seen for cafeteria G, which was mainly due to non-conform core temperatures for CCP7. The fact that this location has the highest sales volume of sandwiches could explain this high number of non-conformities, as this might result in higher work pressure, because of which more mistakes could be made. However, this could also suggest that, although the work pressure and the high sales volume, cafeteria G manages to keep applying correct monitoring and registration of CCPs, whilst other cafeterias might be more neglecting appropriate registration, as for example 0% of non-conformities could be unlikely. Still, it could be expected that because of the higher sales volume, the run time of the portions in counters and bain-maries might be shorter, as offered food products would be used up before they can cool down (reheated products) or heat up (refrigerated products). Also for cafeteria C, CCP7 was most determining for the number of non-conformities. For cafeterias D and E, this was CCP5 and for cafeteria F both CCP5 and CC7 resulted in non-conformities.

5.3.1.2 Internal audits

Table 5.1 shows the scores for the 26 internal audit indicators applying the scoring system as described above. It can be concluded that based on the internal audits, restaurants can be ranked from lowest to highest score as follows: D (50/78), E (52/78), H (66/78), A (66/78), B (67/78), I (69/78), F (70/78), C (74/78), G (76/78). For cafeterias, the raking is as follows: G (50/78), E (51/78), A (66/78), D (67/78), B (70/78), C (72/78), F (76/78). Table 5.1 provides evidence that for restaurants indicators I26 ‘actions in case of non-conformity’, I25 ‘covering food products (cross contamination)’ and I14 ‘no defrosting at room temperature’ are often problematic, as values below 3 are most often reported for these indicators. This means that at many locations meal components are still defrosted at room temperature (I14), without being aware of the consequences of too high temperatures and potential microbiological growth during defrosting. Also prevention of cross-contamination by covering meal components poses difficulties (I25) and in many cases employees do not know how to (re)act in case of non-conformities (I26). For cafeterias, indicator 24 ‘work methodology’ appeared to

Table 5.1: Scoring of restaurants A-I and cafeterias A-G on the 26 internal audit indicators. Scoring system 0-3: 0 never correctly executed; 1 non-conformities noticed and no follow-up/attention/awareness from the employees; 2 non-conformities noticed, but employees are aware of the importance/problem and take action; 3 no problem/non-conformity noticed.

		Restaurants									Cafeterias						
	Internal audit indicator	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**A**	**B**	**C**	**D**	**E**	**F**	**G**
I1	Temperature raw material at reception	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
I2	Display temperatures freezers/refrigerators	3	2	3	1	1	2	3	3	3	1	2	3	3	2	3	1
I3	Registrations temperatures freezers/refrigerators	3	3	3	3	3	2	3	3	3	2	3	3	3	3	3	3
I4	Measurement core temperatures after regeneration (CCP5)	2	3	3	3	3	3	3	3	3	3	2	3	3	1	3	3
I5	Registration core temperatures after regeneration (CCP5)	3	3	3	3	3	2	3	3	3	2	2	3	3	1	3	3
I6	Display temperatures frying equipment and bains-marie (CCP6)	3	3	3	3	2	3	3	1	3	3	3	3	3	3	3	3
I7	Registrations temperatures frying equipment and bains-marie (CCP6)	3	3	3	3	3	3	3	3	3	3	3	3	3	2	3	3
I8	Measurement core temperatures in hot and cold buffets (CCP7)	3	3	3	1	1	2	3	1	3	2	2	2	3	1	3	1
I9	Registration core temperatures in hot and cold buffets (CCP7)	3	3	3	2	2	3	3	2	3	1	3	3	3	1	3	2
I10	Refreshing frying oils	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
I11	FIFO and shelf life dates	3	3	3	3	3	3	3	3	2	3	3	3	2	3	3	3
I12	Labeling of opened packages	2	3	2	2	2	3	3	3	2	3	3	2	3	3	3	2
I13	No chilled products at room temperature	3	0	3	1	1	3	3	3	3	3	3	3	3	2	3	1
I14	No defrosting at room temperature	3	1	2	1	1	2	3	3	3	3	3	3	3	3	3	1
I15	Infrastructure	3	2	3	1	1	3	2	3	2	3	2	3	1	1	3	1
I16	General order	2	3	3	1	2	3	3	3	2	3	3	2	1	1	3	1
I17	General hygiene	2	3	3	1	2	3	3	3	2	3	3	2	1	1	3	1
I18	Calibration and hygiene thermometers	1	3	3	3	2	3	3	3	3	3	3	2	3	3	3	3
I19	Correct use of thermometers	3	2	3	1	2	2	3	1	3	1	3	2	3	1	3	1
I20	Cleaning and disinfection	2	2	3	2	2	2	3	3	2	2	3	3	3	2	2	2
I21	Hygiene personnel	2	3	3	2	3	3	3	3	3	3	3	3	2	3	3	2
I22	General attitude towards food safety of personnel	2	3	3	1	1	3	3	2	3	2	2	3	2	1	3	1
I23	Information and knowledge on allergens	3	3	3	2	2	3	3	3	3	3	3	3	3	3	3	2
I24	Work methodology	2	2	3	2	1	2	3	3	2	2	1	3	1	1	2	2
I25	Covering food products (cross contamination)	2	2	2	2	2	3	2	2	1	3	3	3	3	3	3	2
I26*	Actions in case of non-conformity*	2	3	2	0	1	3	3	0	3	3	3	3	3	0	3	0
Total internal audit score on 78:		**66**	**67**	**74**	**50**	**52**	**70**	**76**	**66**	**69**	**66**	**70**	**72**	**67**	**51**	**76**	**50**

* different interpretation: 0: none of the employees take action; 1: some employees take action; 2: most employees take action; 3: all employees take action (in case of non-conformity)

be of major concern, as e.g. doors of cooling rooms were often left open and at some locations (dirty) cardboard was used to cover sandwiches.

5.3.2 People related verification: food safety climate survey

A total of 92 respondents for the restaurants and 27 respondents for the cafeterias could be used for analysis. The response rate for the restaurants was 61.3%. No exact response rate could be calculated for the cafeterias, as no exact numbers could be provided by the management because of the large number of job students working in the cafeterias. All location responsibles of both restaurants and cafeterias filled out the survey. The HACCP coordinator was not taking part in this. For each of the locations, a distinction was made between the response of the location responsible (one per location) and responses of the staff. The indicators from the 28 indicator-counting food safety climate survey with the most missing values were identified because little MCAR test suggested that the 30 missing values were not at random (p=0.036). Two indicators appeared to give more missing values than all others. For indicator M6 'In my organization, good procedures and instructions concerning hygiene and food safety are in place', in total, 7 missing values were reported and for E3 'working in a hygienic and food safe way is recognized and rewarded' 4 missing values were found over all 92 responses for this indicator. For all other indicators the missing values count ranged between 0 and 2. For non-managerial staff it might be difficult to have a strong opinion on whether procedures and instructions are good (M6). Possibly, non-managerial staff is not familiar with the terms 'procedures' and 'instructions', and do not see the link with their day-to-day tasks. For example, the formal procedure for cleaning and disinfection might have become a natural human habit for them. Also indicator E3 'working in a hygienic and food safe way is recognized and rewarded' appeared to be difficult. Maybe 'rewarded' is too strong and is interpreted as 'physical/financial' rewards, which might be uncommon in certain sectors. However, 'rewards' is a commonly cited commitment indicator influencing employee behavior and is also considered as a safety culture indicator (Griffith et al., 2010a; Pfeffer & Sutton, 1999; Yiannas, 2009).

Frequencies of the different response possibilities for all indicators are given in Tables 5.2a, b, c for the different restaurants (A-I). For cafeterias (A-G), frequencies are displayed in Tables 5.3a, b, c. Both for cafeterias and restaurants, modes were frequently 4 'Agree' and 5 'Totally Agree', which corresponds with a food safety climate which is perceived to be good to very good at a specific location, as indicators are constructed in a way that higher agreement means better perceived climate. Overall, for cafeterias, food safety climate was scored higher than in restaurants (only a few times, 'disagree' or 'neutral' as response). Moreover, in cafeterias location responsible perceptions were at a similar level as staff responses, whereas for restaurants, scores by staff were often higher than scores given by the responsible persons (e.g. restaurants E and A). It might be that some responsibles are more critical and conscientious, considering it as their responsibility to report food safety and hygiene issues.

In order to be able to rank food safety climate scores and compare these with the system and product related verification methods, for each location, the percentage of responses which were 4 ‘Agree’ and 5 ‘Totally agree’ over all indicators and all respondents per location were calculated, excluding the responses of the location responsible which were processed separately. As such, the percentage of responses indicating that the climate is good (‘4: Agree’) to very good (5: ‘Totally Agree’) is obtained. Based on this percentage the food safety climate as perceived by staff and as perceived by the responsible (separately) could be ranked for each location (Table 5.2a, b, c for restaurants, Table 5.3a, b, c for cafeterias). Tables 5.4 and 5.5 give the overview and ranking of the different restaurants and cafeterias according to the three applied verification methods: verification of registration data of critical control points (% of non-conformities), internal audits and food safety (FS) climate score as perceived by staff (without location responsible) and as perceived by the location responsible.

Table 5.2a: Frequencies in absolute numbers (percentage between brackets) per response possibility (five-point Likert answer scale) for each of the 28 indicators of the food safety climate assessment tool for each restaurant. For total food safety climate (FSC), frequencies are given in percentage. Responses for staff are given in normal font, for the location responsible responses (and frequency in percentage for total FSC score) are given in italic font, modes of each FSC indicator are mentioned in bold, n: number of responding employees (without location responsible)+ 1 responsible, R: response of location responsible, superscript: number of missing values

	Resto A (n= 15 + *1*)						**Resto B (n= 4 + *1*)**						**Resto C (n= 4 + *1*)**					
	1	**2**	**3**	**4**	**5**	***R***	**1**	**2**	**3**	**4**	**5**	***R***	**1**	**2**	**3**	**4**	**5**	***R***
L1		1 (6.7)	1 (6.7)	**7 (46.7)**	6 (40)	*4*				1 (25.0)	**3 (75.0)**	*4*			1 (25.0)	1 (25.0)	**2 (50.0)**	*4*
L2		2 (13.3)	**5 (33.3)**	4 (26.7)	4 (26.7)	*3*				**3 (75.0)**	1 (25.0)	*4*			1 (25.0)		**3 (75.0)**	*4*
L3		1 (6.7)	3 (20.0)	5 (33.3)	**6 (40.0)**	*2*			1 (25.0)	**2 (50.0)**	1 (25.0)	*4*					**4 (100)**	*3*
L4			4 (26.7)	5 (33.3)	**6 (40.0)**	*1*			1 (25.0)	1 (25.0)	**2 (50.0)**	*4*					**4 (100)**	*3*
L5			1 (6.7)	**8 (53.3)**	6 (40.0)	*3*			1 (25.0)	1 (25.0)	**2 (50.0)**	*3*				1 (25.0)	**3 (75.0)**	*4*
L6		1 (6.7)	2 (13.3)	**8 (53.3)**	4 (26.7)	*3*			1 (25.0)	1 (25.0)	**2 (50.0)**	*4*				**3 (75.0)**	1 (25.0)	*4*
C1		2 (13.3)	5 (33.3)	**6 (40.0)**	2 (13.3)	*3*			1 (25.0)	**2 (50.0)**	1 (25.0)	*3*			**3 (75.0)**		1 (25.0)	*4*
C2		2 (13.3)	4 (26.7)	**5 (33.3)**	4 (26.7)	*2*			1 (25.0)	1 (25.0)	**2 (50.0)**	*3*			**2 (50.0)**	1 (25.0)	1 (25.0)	*3*
C3			5 (33.3)	5 (33.3)	5 (33.3)	*3*			1 (25.0)		**3 (75.0)**	*4*			1 (25.0)		**3 (75.0)**	*4*
C4		1 (6.7)	4 (26.7)	5 (33.3)	5 (33.3)	*4*				2 (50.0)	2 (50.0)	*2*		**3 (75.0)**	1 (25.0)			*4*
C5			5 (33.3)	**6 (40.0)**	4 (26.7)	*5*				**3 (75.0)**	1 (25.0)	*5*				2 (50.0)	2 (50.0)	*5*
E1		1 (6.7)	1 (6.7)	**7 (46.7)**	6 (40.0)	*4*				2 (50.0)	2 (50.0)	*4*				**3 (75.0)**	1 (25.0)	*4*
E2		1 (6.7)	1 (6.7)	**8 (53.3)**	5 (33.3)	*3*			1 (25.0)	**2 (50.0)**	1 (25.0)	*4*					**4 (100)**	*4*
E3		1 (6.7)	4 (26.7)	**6 (40.0)**	4 (26.7)	*4*			**2 (50.0)**	1 (25.0)	1 (25.0)	*3*			1 (25.0)	**2 (50.0)**	1 (25.0)	*2*
E4			2 (13.3)	**8 (53.3)**	5 (33.3)	*4*				2 (50.0)	2 (50.0)	*3*				1 (25.0)	**3 (75.0)**	*3*
E5			4 (26.7)	**7 (46.7)**	4 (26.7)	*5*			1 (25.0)	1 (25.0)	**2 (50.0)**	*2*					**4 (100)**	*4*
E6		1 (6.7)	5 (33.3)	4 (26.7)	5 (33.3)	*5*			1 (25.0)	**2 (50.0)**	1 (25.0)	*3*			1 (25.0)	1 (25.0)	**2 (50.0)**	*4*
M1			2 (13.3)	**10 (66.7)**	3 20.0)	*3*			**2 (50.0)**	1 (25.0)	1 (25.0)	*5*			1 (25.0)	**3 (75.0)**		*3*
M2			4 (26.7)	**9 (60.0)**	2 (13.3)	*1*			1 (25.0)	1 (25.0)	**2 (50.0)**	*3*			**3 (75.0)**	1 (25.0)		*2*
M3			**6 (40.0)**	5 (33.3)	4 (26.7)	*3*			1 (25.0)	**3 (75.0)**		*4*				**3 (75.0)**	1 (25.0)	*4*
M4		1 (6.7)^{1}	**7 (46.7)^{1}**	4 (26.7)^{1}	2 (13.3)^{1}	*3*			1 (25.0)	**2 (50.0)**	1 (25.0)	*4*			1 (25.0)	**3 (75.0)**		*3*
M5	1 (6.7)^{1}	1 (6.7)^{1}	4 (26.7)^{1}	**7 (46.7)^{1}**	1 (6.7)^{1}	*1*		1 (25.0)	1 (25.0)	1 (25.0)	1 (25.0)	*4*					**4 (100)**	*3*
M6		1 (6.7)^{3}	2 (13.3)^{3}	**6 (40.0)^{3}**	3 (20.0)^{3}	*3*				1 (25.0)^{1}	**2 (50.0)^{1}**	*4*					**4 (100)**	*4*
R1		1 (6.7)	4 (26.7)	**6 (40.0)**	4 (26.7)	*3*			1 (25.0)^{1}	1 (25.0)^{1}	1 (25.0)^{1}	*3*				1 (25.0)	**3 (75.0)**	*4*
R2			3 (20.0)	**10 (66.7)**	2 (13.3)	*5*				**3 (75.0)**	1 (25.0)	*5*					**4 (100)**	*5*
R3			**7 (46.7)**	5 (33.3)	3 (20.0)	*4*		1 (25.0)		**2 (50.0)**	1 (25.0)	*3*				1 (25.0)	**3 (75.0)**	*3*
R4			3 (20.0)	**8 (53.3)**	4 (26.7)	*4*				**3 (75.0)**	1 (25.0)	*4*				1 (25.0)	**3 (75.0)**	*3*
R5		1 (6.7)	3 (20.0)	**7 (46.7)**	4 (26.7)	*5*		1 (25.0)	1 (25.0)	**2 (50.0)**		*5*				2 (50.0)	2 (50.0)	*4*
FSC	(0.2)	(4.5)	(24.0)	**(43.1)**	(26.9)			(2.7)	(17.9)	**(42.0)**	(35.7)			(2.7)	(14.3)	(26.8)	**(56.3)**	
total	*(10.7)*	*(7.1)*	***(39.3)***	*(25.0)*	*(17.9)*			*(7.1)*	*(32.1)*	***(46.4)***	*(14.3)*			*(7.1)*	*(35.7)*	***(50.0)***	*(7.1)*	

Table 5.2b: Frequencies in absolute numbers (percentage between brackets) per response possibility (five-point Likert answer scale) for each of the 28 indicators of the food safety climate assessment tool for each restaurant. For total food safety climate (FSC), frequencies are given in percentage. Responses for staff are given in normal font, for the location responsible responses (and frequency in percentage for total FSC score) are given in italic font, modes of each FSC indicator are mentioned in bold, n: number of responding employees (without location responsible)+ 1 responsible, R: response of location responsible, superscript: number of missing values

	Resto D (n= 10 + *1*)						**Resto E (n= 6 + *1*)**						**Resto F (n= 10 + *1*)**					
	1	**2**	**3**	**4**	**5**	***R***	**1**	**2**	**3**	**4**	**5**	***R***	**1**	**2**	**3**	**4**	**5**	***R***
L1		1 (10.0)	2 (20.0)	**4 (40.0)**	3 (30.0)	*4*				**3 (50.0)**	**3 (50.0)**	*4*				**7 (70.0)**	3 (30.0)	*5*
L2		1 (10.0)	**3 (30.0)**	**3 (30.0)**	**3 (30.0)**	*4*				**3 (50.0)**	**3 (50.0)**	*3*				**7 (70.0)**	3 (30.0)	*4*
L3		1 (10.0)	**5 (50.0)**	1 (10.0)	3 (30.0)	*4*				**4 (66.7)**	2 (33.3)	*4*			1 (10.0)	**5 (50.0)**	4 (40.0)	*4*
L4	1 (10.0)	1 (10.0)	2 (20.0)	**4 (40.0)**	2 (20.0)	*3*			1 (16.7)	2 (33.3)	**3 (50.0)**	*3*			1 (10.0)	**5 (50.0)**	4 (40.0)	*3*
L5		1 (10.0)	3 (30.0)	**5 (50.0)**	1 (10.0)	*4*				**3 (50.0)**	**3 (50.0)**	*4*			1 (10.0)	4 (40.0)	**5 (50.0)**	*3*
L6		1 (10.0)	**4 (40.0)**	**4 (40.0)**	1 (10.0)	*4*			1 (16.7)	2 (33.3)	**3 (50.0)**	*4*			1 (10.0)	**6 (60.0)**	3 (30.0)	*3*
C1		1 (10.0)	**4 (40.0)**	**4 (40.0)**	1 (10.0)	*2*			2 (33.3)	**4 (66.7)**		*2*			2 (20.0)	**8 (80.0)**		^{1}
C2		2 (20.0)	1 (10.0)	**6 (60.0)**	1 (10.0)	*3*				**5 (83.3)**	1 (16.7)	*2*			2 (20.0)	**6 (60.0)**	2 (20.0)	^{1}
C3		1 (10.0)	3 (30.0)	**4 (40.0)**	2 (20.0)	*4*	1 (16.7)			1 (16.7)	**4 (66.7)**	*4*			2 (20.0)	3 (30.0)	**5 (50.0)**	^{1}
C4			4 (40.0)	**5 (50.0)**	1 (10.0)	*3*		1 (16.7)		2 (33.3)	**3 (50.0)**	*3*			3 (30.0)	3 (30.0)	**4 (40.0)**	^{1}
C5			4 (40.0)	**5 (50.0)**	1 (10.0)	*4*				**4 (66.7)**	2 (33.3)	*5*				**7 (70.0)**	3 (30.0)	^{1}
E1			4 (40.0)	**5 (50.0)**	1 (10.0)	*4*				**3 (50.0)**	**3 (50.0)**	*4*			1 (10.0)	4 (40.0)	**5 (50.0)**	^{1}
E2		1 (10.0)	3 (30.0)	**6 (60.0)**		*2*				**5 (83.3)**	1 (16.7)	*5*			1 (10.0)	**8 (80.0)**	1 (10.0)	^{1}
E3		1 (10.0)	**6 (60.0)**	3 (30.0)		*2*			**2 (33.3)**^{1}	1 (16.7)^{1}	**2 (33.3)**^{1}	*2*			2 (20.0)	**8 (80.0)**		^{1}
E4		2 (20.0)	**3 (30.0)**	**3 (30.0)**	2 (20.0)	*3*				**3 (50.0)**	**3 (50.0)**	*3*			1 (10.0)	4 (40.0)	**5 (50.0)**	^{1}
E5		2 (20.0)	2 (20.0)	**5 (50.0)**	1 (10.0)	*3*			1 (16.7)	1 (16.7)	**4 (66.7)**	*3*				**7 (70.0)**	3 (30.0)	^{1}
E6		1 (10.0)	**5 (50.0)**	3 (30.0)	1 (10.0)	*3*				**4 (66.7)**	2 (33.3)	*3*			2 (20.0)	**6 (60.0)**	2 (20.0)	^{1}
M1		1 (10.0)	3 (30.0)	**5 (50.0)**	1 (10.0)	*2*			1 (16.7)	**3 (50.0)**	2 (33.3)	*3*		1 (10.0)	2 (20.0)	3 (30.0)	**4 (40.0)**	*5*
M2		1 (10.0)	2 (20.0)	**6 (60.0)**	1 (10.0)	*2*			**2 (33.3)**	**2 (33.3)**	**2 (33.3)**	*4*		1 (10.0)	2 (20.0)	3 (30.0)	**4 (40.0)**	*5*
M3		1 (10.0)	2 (20.0)	**5 (50.0)**	2 (20.0)	*3*			1 (16.7)	2 (33.3)	**3 (50.0)**	*4*			2 (20.0)	2 (20.0)	**6 (60.0)**	*4*
M4	1 (10.0)	1 (10.0)	2 (20.0)	**6 (60.0)**		*3*			**2 (33.3)**	**2 (33.3)**	**2 (33.3)**	*3*			**4 (40.0)**	3 (30.0)	3 (30.0)	*5*
M5		**4 (40.0)**	**4 (40.0)**	1 (10.0)	1 (10.0)	*4*			**3 (50.0)**	2 (33.3)	1 (16.7)	*3*		3 (30.0)	1 (10.0)	**6 (60.0)**		*4*
M6			**5 (50.0)**	4 (40.0)	1 (10.0)	*4*			1 (16.7)	2 (33.3)	**3 (50.0)**	*4*		1 (10.0)	3 (30.0)	**5 (50.0)**	1 (10.0)	*4*
R1		1 (10.0)	1 (10.0)	**8 (80.0)**		*3*				**4 (66.7)**	2 (33.3)	*4*			1 (10.0)	**6 (60.0)**	3 (30.0)	*5*
R2			3 (30.0)	**5 (50.0)**	2 (20.0)	*3*			1 (16.7)	**3 (50.0)**	2 (33.3)	*4*		1 (10.0)	1 (10.0)	**4 (40.0)**	**4 (40.0)**	*5*
R3			**6 (60.0)**	4 (40.0)		*2*				**4 (66.7)**	2 (33.3)	*5*			1 (10.0)	**8 (80.0)**	1 (10.0)	*5*
R4		1 (10.0)	**4 (40.0)**	**4 (40.0)**	1 (10.0)	*3*				**4 (66.7)**	2 (33.3)	*3*		1 (10.0)	1 (10.0)	**6 (60.0)**	2 (20.0)	*2*
R5		1 (10.0)	1 (10.0)	**6 (60.0)**	2 (20.0)	*2*				**4 (66.7)**	2 (33.3)	*4*		1 (10.0)	1 (10.0)	**4 (40.0)**	**4 (40.0)**	*5*
FSC	(0.7)	(10.0)	(32.5)	**(44.3)**	(12.5)		(0.6)	(0.6)	(10.7)	**(48.8)**	(38.7)			(3.2)	(13.9)	**(53.2)**	(29.6)	
total		*(21.4)*	***(42.9)***	*(35.7)*				*(10.7)*	*(35.7)*	***(42.9)***	*(10.7)*			*(3.6)*	*(10.7)*	*(17.9)*	***(28.6)***	

Table 5.2c: Frequencies in absolute numbers (percentage between brackets) per response possibility (five-point Likert answer scale) for each of the 28 indicators of the food safety climate assessment tool for each restaurant. For total food safety climate (FSC), frequencies are given in percentage. Responses for staff are given in normal font, for the location responsible responses (and frequency in percentage for total FSC score) are given in italic font, modes of each FSC indicator are mentioned in bold, n: number of responding employees (without location responsible)+ 1 responsible, R: response of location responsible, superscript: number of missing values

	Resto G (n= 19 + *1*)						**Resto H (n= 8 + *1*)**						**Resto I (n= 7 + *1*)**					
	1	**2**	**3**	**4**	**5**	***R***	**1**	**2**	**3**	**4**	**5**	***R***	**1**	**2**	**3**	**4**	**5**	***R***
L1				**10 (52.6)**	9 (47.4)	*5*				**4 (50.0)**	**4 (50.0)**	*5*				2 (28.6)	**5 (71.4)**	*5*
L2			2 (10.5)	**10 (52.6)**	7 (36.8)	*5*				**4 (50.0)**	**4 (50.0)**	*4*					**7 (100)**	*5*
L3		1 (5.3)[1]	2 (10.5)[1]	**8 (42.1)[1]**	7 (36.8)[1]	*5*			1 (12.5)	3 (37.5)	**4 (50.0)**	*5*			1 (14.3)		**6 (85.7)**	*5*
L4		2 (10.5)	3 (15.8)	**8 (42.1)**	6 (31.6)	*3*		1 (12.5)		**4 (50.0)**	3 (37.5)	*4*			2 (28.6)	1 (14.3)	**4 (57.1)**	*4*
L5			5 (26.3)	**10 (52.6)**	4 (21.1)	*4*			1 (12.5)	**4 (50.0)**	3 (37.5)	*5*					**7 (100)**	*4*
L6			3 (15.8)	**10 (52.6)**	6 (31.6)	*5*			2 (25.0)	2 (25.0)	**4 (50.0)**	*5*				3 (42.9)	**4 (57.1)**	*5*
C1		2 (10.5)	7 (36.8)	**8 (42.1)**	2 (10.5)	*3*			2 (25.0)	**4 (50.0)**	2 (25.0)	*4*				**4 (57.1)**	3 (42.9)	*4*
C2		1 (5.3)	5 (26.3)	**11 (57.9)**	2 (10.5)	*3*			1 (12.5)	**4 (50.0)**	3 (37.5)	*4*			1 (14.3)	2 (28.6)	**4 (57.1)**	*4*
C3		3 (15.8)	1 (5.3)	**9 (47.4)**	6 (31.6)	*4*				**5 (62.5)**	3 (37.5)	*4*				3 (42.9)	**4 (57.1)**	*4*
C4		1 (5.3)	3 (15.8)	6 (31.6)	**9 (47.4)**	*5*		1 (12.5)	1 (12.5)	**4 (50.0)**	2 (25.0)	*5*			2 (28.6)	2 (28.6)	**3 (42.9)**	*4*
C5		1 (5.3)[1]	1 (5.3)[1]	**10 (52.6)[1]**	6 (31.6)[1]	*5*		1 (12.5)		**6 (75.0)**	1 (12.5)	*4*				1 (12.5)	**6 (85.7)**	*5*
E1			5 (26.3)	4 (21.1)	**10 (52.6)**	*4*		1 (12.5)		2 (25.0)	**5 (62.5)**	*5*			2 (28.6)	1 (14.3)	**4 (57.1)**	*5*
E2		1 (5.3)	4 (21.1)	**8 (42.1)**	6 (31.6)	*5*			1 (12.5)	2 (25.0)	**5 (62.5)**	*3*			2 (28.6)	1 (14.3)	**4 (57.1)**	*5*
E3		3 (15.8)	**9 (47.4)**	3 (15.8)	4 (21.1)	*3*		1 (12.5)[1]	1 (12.5)[1]	**4 (50.0)[1]**	1 (12.5)[1]	*3*				**3 (42.9)[1]**	**3 (42.9)[1]**	*3*
E4		3 (15.8)	2 (10.5)	**10 (52.6)**	4 (21.1)	*4*	1 (12.5)			3 (37.5)	**4 (50.0)**	*4*			2 (28.6)		**5 (71.4)**	*4*
E5			3 (15.8)[1]	5 (26.3)[1]	**10 (52.6)[1]**	*4*			1 (12.5)	**4 (50.0)**	3 (37.5)	*5*				1 (14.3)	**6 (85.7)**	*5*
E6		2 (10.5)	3 (15.8)	**10 (52.6)**	4 (21.1)	*4*		1 (12.5)		**4 (50.0)**	3 (37.5)	*5*				2 (28.6)	**5 (71.4)**	*4*
M1		1 (5.3)	4 (21.1)	**9 (47.4)**	5 (26.3)	*3*	1 (12.5)			**4 (50.0)**	3 (37.5)	*3*			2 (28.6)	**3 (42.9)**	2 (28.6)	*4*
M2		1 (5.3)	4 (21.1)	**13 (68.4)**	1 (5.3)	*3*	1 (12.5)[1]	1 (12.5)[1]		**4 (50.0)[1]**	1 (12.5)[1]	*3*			1 (14.3)	**4 (57.1)**	2 (28.6)	*3*
M3		1 (5.3)[1]	4 (21.1)[1]	**8 (42.1)[1]**	5 (26.3)[1]	*3*			2 (25.0)	2 (25.0)	**4 (50.0)**	*5*			1 (14.3)	**4 (57.1)**	2 (28.6)	*3*
M4		1 (5.3)	4 (21.1)	**7 (36.8)**	**7 (36.8)**	*5*		1 (12.5)[1]		**4 (50.0)[1]**	2 (25.0)[1]	*4*				3 (42.9)	**4 (57.1)**	*3*
M5		2 (10.5)	4 (21.1)	**8 (42.1)**	5 (26.3)	*4*	1 (12.5)			**4 (50.0)**	3 (37.5)	*5*			1 (14.3)	**3 (42.9)**	**3 (42.9)**	*4*
M6		1 (5.3)[2]	2 (10.5)[2]	**7 (36.8)[2]**	**7 (36.8)[2]**	*4*		1 (12.5)[1]		**3 (37.5)[1]**	**3 (37.5)[1]**	*5*			1 (14.3)	**4 (57.1)**	2 (28.6)	*4*
R1		1 (5.3)	2 (10.5)	**11 (57.9)**	5 (26.3)	*4*	1 (12.5)			**4 (50.0)**	3 (37.5)	*4*	**3 (42.9)**		2 (28.6)	2 (28.6)		*4*
R2			1 (5.3)	**14 (73.7)**	4 (21.1)	*4*			1 (12.5)	**4 (50.0)**	3 (37.5)	*4*			1 (14.3)	2 (28.6)	**4 (57.1)**	*4*
R3			**7 (36.8)**	**7 (36.8)**	5 (26.3)	*4*		1 (12.5)		**5 (62.5)**	2 (25.0)	*4*			2 (28.6)	1 (14.3)	**4 (57.1)**	*4*
R4			4 (21.1)	**11 (57.9)**	4 (21.1)	*4*				**5 (62.5)**	3 (37.5)	*4*			1 (14.3)	2 (28.6)	**4 (57.1)**	*4*
R5			2 (10.5)	**11 (57.9)**	6 (31.6)	*5*				**4 (50.0)**	**4 (50.0)**	*5*			1 (14.3)	1 (14.3)	**5 (71.4)**	*4*
FSC total		(5.3)	(18.0) *(25.0)*	**(46.2)** ***(42.9)***	(29.3) *(32.1)*		(2.2)	(4.5)	(6.3) *(14.3)*	**(47.3)** ***(42.9)***	(37.9) ***(42.9)***		(1.5)		(11.7) *(14.3)*	(28.1) ***(57.1)***	**(58.2)** *(28.6)*	

Table 5.3a: Frequencies in absolute numbers (percentage between brackets) per response possibility (five-point Likert answer scale) for each of the 28 indicators of the food safety climate assessment tool for each restaurant. For total food safety climate (FSC), frequencies are given in percentage. Responses for staff are given in normal font, for the location responsible responses (and frequency in percentage for total FSC score) are given in italic font, modes of each FSC indicator are mentioned in bold, n: number of responding employees (without location responsible)+ 1 responsible, R: response of location responsible, superscript: number of missing values

	Cafeteria A (n= 5 + *1*)						**Cafeteria B (n= 2 + *1*)**						**Cafeteria C (n= 5 + *1*)**					
	1	**2**	**3**	**4**	**5**	***R***	**1**	**2**	**3**	**4**	**5**	***R***	**1**	**2**	**3**	**4**	**5**	***R***
L1				**3 (60.0)**	2 (40.0)	*5*					2 (100)	*4*				1 (20.0)	**4 (80.0)**	*5*
L2			1 (20.0)	**2 (40.0)**	**2 (40.0)**	*5*					2 (100)	*5*				**3 (60.0)**	2 (40.0)	*5*
L3				**3 (60.0)**	2 (40.0)	*4*				1 (50.0)	1 (50.0)	*5*				**3 (60.0)**	2 (40.0)	*5*
L4				**3 (60.0)**	2 (40.0)	*5*				1 (50.0)	1 (50.0)	*4*			1 (20.0)	**2 (40.0)**	**2 (40.0)**	*5*
L5			1 (20.0)	**2 (40.0)**	**2 (40.0)**	*5*				1 (50.0)	1 (50.0)	*4*				**3 (60.0)**	2 (40.0)	*4*
L6			**2 (40.0)**	1 (20.0)	**2 (40.0)**	*5*				1 (50.0)	1 (50.0)	*5*				**3 (60.0)**	2 (40.0)	*4*
C1			2 (40.0)	**3 (60.0)**		*5*			1 (50.0)	1 (50.0)		*4*			**2 (40.0)**	**2 (40.0)**	1 (20.0)	*4*
C2				**4 (80.0)**	1 (20.0)	*5*			1 (50.0)	1 (50.0)		*4*				**4 (80.0)**	1 (20.0)	*4*
C3				2 (40.0)	**3 (60.0)**	*5*				1 (50.0)	1 (50.0)	*4*				**3 (60.0)**	2 (40.0)	*4*
C4				**3 (60.0)**	2 (40.0)	*5*				1 (50.0)	1 (50.0)	*5*				1 (20.0)	**4 (80.0)**	*5*
C5				2 (40.0)	**3 (60.0)**	*5*			1 (50.0)		1 (50.0)	*4*				1 (20.0)	**4 (80.0)**	*5*
E1			1 (20.0)	**3 (60.0)**	1 (20.0)	*5*					2 (100)	*5*				**3 (60.0)**	2 (40.0)	*5*
E2				**4 (80.0)**	1 (20.0)	*5*				1 (50.0)	1 (50.0)	*4*				2 (40.0)	**3 (60.0)**	*4*
E3		1 (20.0)		**3 (60.0)**	1 (20.0)	*5*			1 (50.0)		1 (50.0)	*3*		1 (20.0)	1 (20.0)	**3 (60.0)**		*3*
E4				**4 (80.0)**	1 (20.0)	*5*					2 (100)	*5*				**4 (80.0)**	1 (20.0)	*4*
E5			1 (20.0)	**3 (60.0)**	1 (20.0)	*5*					2 (100)	*4*				2 (40.0)	**3 (60.0)**	*4*
E6			2 (40.0)	**3 (60.0)**		*5*			1 (50.0)		1 (50.0)	*4*			1 (20.0)	**2 (40.0)**	**2 (40.0)**	*4*
M1			1 (20.0)	2 (40.0)	2 (40.0)	*4*				1 (50.0)	1 (50.0)	*3*		1 (20.0)		**3 (60.0)**	1 (20.0)	*4*
M2			1 (20.0)	2 (40.0)	2 (40.0)	*4*				1 (50.0)	1 (50.0)	*3*				**5 (100)**		*4*
M3			1 (20.0)	**4 (80.0)**		*5*				2 (100)		*3*				**3 (60.0)**	2 (40.0)	*5*
M4			2 (40.0)	**3 (60.0)**		*5*			1 (50.0)		1 (50.0)	*4*			**3 (60.0)**	1 (20.0)	1 (20.0)	*5*
M5			**3 (60.0)**	2 (40.0)		*5*			1 (50.0)	1 (50.0)		*5*		1 (20.0)	**2 (40.0)**	**2 (40.0)**		*4*
M6			**2 (40.0)**	1 (20.0)	**2 (40.0)**	*4*				2 (100)		*5*				**4 (80.0)**	1 (20.0)	*4*
R1			1 (20.0)	**2 (40.0)**	**2 (40.0)**	*5*				2 (100)		*4*			1 (20.0)	**2 (40.0)**	**2 (40.0)**	*5*
R2				**3 (60.0)**	2 (40.0)	*5*				1 (50.0)	1 (50.0)	*4*				**5 (100)**		*5*
R3				**3 (60.0)**	2 (40.0)	*5*				1 (50.0)	1 (50.0)	*4*				**4 (80.0)**	1 (20.0)	*4*
R4			1 (20.0)	**3 (60.0)**	1 (20.0)	*5*				1 (50.0)	1 (50.0)	*4*				**3 (60.0)**	2 (40.0)	*4*
R5	1 (20.0)	1 (20.0)	1 (20.0)	**2 (40.0)**		*5*				1 (50.0)	1 (50.0)	*4*		1 (20.0)		**3 (60.0)**	1 (20.0)	*4*
FSC total	(0.7)	(1.4)	(16.4)	**(53.6)** *(14.3)*	(27.9) ***(85.7)***				(12.5) *(14.3)*	(39.3) ***(57.1)***	**(48.2)** *(28.6)*			(2.9)	(7.9) *(3.6)*	**(55.0)** ***(57.1)***	(34.3) *(39.3)*	

Table 5.3b: Frequencies in absolute numbers (percentage between brackets) per response possibility (five-point Likert answer scale) for each of the 28 indicators of the food safety climate assessment tool for each restaurant. For total food safety climate (FSC), frequencies are given in percentage. Responses for staff are given in normal font, for the location responsible responses (and frequency in percentage for total FSC score) are given in italic font, modes of each FSC indicator are mentioned in bold, n: number of responding employees (without location responsible)+ 1 responsible, R: response of location responsible, superscript: number of missing values

	Cafeteria D (n= 2 + *1*)						**Cafeteria E (n= 1 + *1*)**						**Cafeteria F (n= 4 + *1*)**					
	1	**2**	**3**	**4**	**5**	***R***	**1**	**2**	**3**	**4**	**5**	***R***	**1**	**2**	**3**	**4**	**5**	***R***
L1					2 (100)	*5*					1 (100)	*5*				1 (25.0)	**3 (75.0)**	*5*
L2					2 (100)	*5*					1 (100)	*5*				1 (25.0)	**3 (75.0)**	*5*
L3					2 (100)	*5*					1 (100)	*5*				1 (25.0)	**3 (75.0)**	*5*
L4				1 (50.0)	1 (50.0)	*5*					1 (100)	*4*				1 (25.0)	**3 (75.0)**	*4*
L5				1 (50.0)	1 (50.0)	*5*					1 (100)	*5*				**2 (50.0)**	**2 (50.0)**	*4*
L6				1 (50.0)	1 (50.0)	*5*					1 (100)	*4*				**2 (50.0)**	**2 (50.0)**	*4*
C1				1 (50.0)	1 (50.0)	*5*					1 (100)	*2*				**2 (50.0)**	**2 (50.0)**	*4*
C2				1 (50.0)	1 (50.0)	*5*					1 (100)	*2*				**2 (50.0)**	**2 (50.0)**	*4*
C3				1 (50.0)	1 (50.0)	*5*					1 (100)	*4*				1 (25.0)	**3 (75.0)**	*4*
C4				1 (50.0)	1 (50.0)	*5*					1 (100)	*3*				1 (25.0)	**3 (75.0)**	*4*
C5					2 (100)	*5*					1 (100)	*4*				1 (25.0)	**3 (75.0)**	*4*
E1		1 (50.0)			1 (50.0)	*5*					1 (100)	*4*				**2 (50.0)**	**2 (50.0)**	*4*
E2				1 (50.0)	1 (50.0)	*4*					1 (100)	*3*				1 (25.0)	**3 (75.0)**	*5*
E3				1 (50.0)	1 (50.0)	*5*					1 (100)	*4*				2 (50.0)	**2 (50.0)**	*4*
E4				1 (50.0)	1 (50.0)	*5*					1 (100)	*4*				**2 (50.0)**	**2 (50.0)**	*4*
E5				1 (50.0)	1 (50.0)	*5*					1 (100)	*5*				**2 (50.0)**	**2 (50.0)**	*3*
E6				1 (50.0)	1 (50.0)	*5*					1 (100)	*4*				1 (25.0)	**3 (75.0)**	*4*
M1				1 (50.0)	1 (50.0)	*4*				1 (100)		*3*				1 (25.0)	**3 (75.0)**	*4*
M2				1 (50.0)	1 (50.0)	*3*				1 (100)		*3*			1 (25.0)	1 (25.0)	**2 (50.0)**	*3*
M3					2 (100)	*5*				1 (100)		*2*				**3 (75.0)**	1 (25.0)	*3*
M4				1 (50.0)	1 (50.0)	*5*				1 (100)		*5*			1 (25.0)	**3 (75.0)**		*4*
M5				1 (50.0)	1 (50.0)	*4*				1 (100)		*4*				**3 (75.0)**	1 (25.0)	*4*
M6				1 (50.0)	1 (50.0)	*5*				1 (100)		*5*				**2 (50.0)**	**2 (50.0)**	*4*
R1				1 (50.0)	1 (50.0)	*5*				1 (100)		*5*				**2 (50.0)**	**2 (50.0)**	*4*
R2					2 (100)	*5*				1 (100)		*5*				**2 (50.0)**	**2 (50.0)**	*4*
R3					2 (100)	*5*					1 (100)	*4*				**2 (50.0)**	**2 (50.0)**	*4*
R4					2 (100)	*4*					1 (100)	*4*				1 (25.0)	**3 (75.0)**	*4*
R5					2 (100)	*5*					1 (100)	*5*				1 (25.0)	**3 (75.0)**	*4*
FSC		(1.8)		(32.1)	**(66.1)**					(28.6)	**(71.4)**				(1.8)	(41.1)	**(57.1)**	
total			*(3.6)*	*(14.3)*	***(82.1)***			*(10.7)*	*(14.3)*	***(39.3)***	*(35.7)*				*(10.7)*	***(75.0)***	*(14.3)*	

Table 5.3c: Frequencies in absolute numbers (percentage between brackets) per response possibility (five-point Likert answer scale) for each of the 28 indicators of the food safety climate assessment tool for each restaurant. For total food safety climate (FSC), frequencies are given in percentage. Responses for staff are given in normal font, for the location responsible responses (and frequency in percentage for total FSC score) are given in italic font, modes of each FSC indicator are mentioned in bold, n: number of responding employees (without location responsible)+ 1 responsible, R: response of location responsible, superscript: number of missing values

	Cafeteria G (n= 1 + *1*)					
	1	**2**	**3**	**4**	**5**	***R***
L1					1 (100)	*5*
L2					1 (100)	*4*
L3					1 (100)	*5*
L4					1 (100)	*5*
L5					1 (100)	*4*
L6					1 (100)	*4*
C1					1 (100)	*4*
C2					1 (100)	*4*
C3					1 (100)	*4*
C4					1 (100)	*4*
C5					1 (100)	*4*
E1					1 (100)	*4*
E2					1 (100)	*4*
E3					1 (100)	*4*
E4					1 (100)	*4*
E5					1 (100)	*4*
E6					1 (100)	*4*
M1					1 (100)	*3*
M2					1 (100)	*3*
M3				1 (100)		*3*
M4					1 (100)	*3*
M5					1 (100)	*4*
M6					1 (100)	*4*
R1					1 (100)	*4*
R2					1 (100)	*4*
R3					1 (100)	*3*
R4					1 (100)	*4*
R5					1 (100)	*5*
FSC				(3.6)	**(96.4)**	
total			*(17.9)*	***(67.9)***	*(14.3)*	

5.4 Discussion

The objective of this chapter was to perform a method triangulation to assess different aspects of food safety culture within food service operations through two system and product related verification methods (belonging to the techno-managerial route) and a people related method (belonging to the human route) by self-assessment. Comparing the results of the two system and product related verification methods, shows that internal audits (total internal audit scores: Tables 5.1, 5.4 and 5.5) and verification of CCP monitoring data (total percentage of non-conformities: Figure 5.4 and Tables 5.4 and 5.5) gave similar results in most of the restaurant and cafeteria locations. For the restaurants, both methods identified restaurants D, E and H to be at the lowest level of FSMS performance (i.e. the highest number of registered non-conformities in their CCP registration and lower internal audit score). Linking these findings with the people related method, it can be seen in Table 5.4 (ranking) that in restaurant D both employees (56.8% 'Agree' or 'Totally agree') and location responsible (35.7% 'Agree' or 'Totally agree') perceive the food safety climate substantially lower than other restaurants. These results suggest that both system and product related measurement methods (internal audits and verification of monitoring data) indicate that FSMS performance in restaurant D is at a lower level, which is acknowledged by the location's staff and responsible through their responses for the food safety climate self-assessment survey. They recognize that there are issues with food safety and hygiene control measures at their location. As such, the perception of food safety and hygiene performance by staff and responsible is in line with results obtained through the system and product related methods. For all other locations, food safety climate scores as perceived by staff were rather high (range : 70.0%-87.5% 'Agree' and 'Totally agree'). Interestingly, based on verification of registration data, the percentage of registered non-conformities of restaurant H (9.18%) appeared to be substantially higher compared to the other restaurants, which could be mainly attributed to problems with bain-maries (CCP6). Although, not ranked lowest according to the internal audit results, problems with CCP6 are also noticed in Table 5.1, as indicator I6 'display temperatures frying equipment and bains-marie (CCP6)' was equal to 1, because at the moment of the audit, bain-maries temperatures were below 80°C, without employees informing responsibles and taking action. They only registered the temperatures, without being aware of the potential consequences of this non-conformity. However, the fact that I7 'registrations temperatures frying equipment and bain-maries (CCP6)' was equal to 3, suggests that registrations of bain-maries temperatures are done correctly. Still, this was not the case for registrations of CCP7 (I9 'registration core temperatures in hot and cold buffets (CCP7)'). Temperatures which were registered, did not align with temperatures measured by the auditor during the audit, although thermometers were calibrated. Another issue noticed during the audit in restaurant H was the fact

Table 5.4: Overview and ranking (from highest to lowest level of food safety performance) of the different restaurants (A-I) according to the three applied methods: verification of registration data (% of non-conformities), internal audits and Food Safety (FS) Climate score as perceived by staff (without location responsible) and as perceived by the location responsible.

Ranking based on % non-conformities	% non- conformities	Ranking based on internal audit score	Internal audit score on 78	Ranking based on FS Climate score by staff (non responsible)	FS Climate score by staff (in %)	Ranking based on FS Climate score by responsible	FS Climate score by location responsible (in %)
Restaurant F	1.4	Restaurant G	76	Restaurant E	87.5	Restaurant H	85.8
Restaurant G	1.81	Restaurant C	74	Restaurant I	86.3	Restaurant I	85.7
Restaurant A	1.82	Restaurant F	70	Restaurant H	85.2	Restaurant G	75
Restaurant I	4.39	Restaurant I	69	Restaurant C	83.1	Restaurant B	60.7
Restaurant B	4.78	Restaurant B	67	Restaurant F	82.8	Restaurant C	57
Restaurant C	5.4	Restaurant A	66	Restaurant B	77.7	Restaurant E	53.6*
Restaurant D	6.34	Restaurant H	66	Restaurant G	75.5	Restaurant F	46.5
Restaurant E	6.42	Restaurant E	52	Restaurant A	70.0	Restaurant A	42.9
Restaurant H	9.18	Restaurant D	50	Restaurant D	56.8	Restaurant D	35.7

*:11 of 28 indicators not filled out; recalculated percentage based on valid responses: 17 valid responses

Table 5.5: Overview and ranking (from highest to lowest level of food safety performance) of the different cafeterias (A-G) according to the three applied methods: verification of registration data (% of non-conformities), internal audits and Food Safety (FS) Climate score as perceived by staff (without location responsible) and as perceived by the location responsible.

Ranking based on % non-conformities	% non- conformities	Ranking based on internal audit score	Internal audit score on 78	Ranking based on FS Climate score by staff (non responsible)	FS Climate score by staff (in %)	Ranking based on FS Climate score by responsible	FS Climate score by location responsible (in %)
Cafeteria A	0	Cafeteria F	76	Cafeteria E	100	Cafeteria A	100
Cafeteria B	0	Cafeteria C	72	Cafeteria G	100	Cafeteria C	96.4
Cafeteria C	0.06	Cafeteria B	70	Cafeteria F	98.2	Cafeteria D	96.4
Cafeteria F	0.18	Cafeteria D	67	Cafeteria D	98.2	Cafeteria F	89.3
Cafeteria E	0.79	Cafeteria A	66	Cafeteria C	91.4	Cafeteria B	85.7
Cafeteria D	2.16	Cafeteria E	51	Cafeteria B	87.5	Cafeteria G	82.2
Cafeteria G	6.88	Cafeteria G	50	Cafeteria A	81.5	Cafeteria E	75

that employees did not know how to act in case of non-conformities (I26 'actions in case of non-conformity' =0). Moreover, many employees did not know the correct threshold limits for CCPs, which was revealed during the internal audits. So for restaurant H, system and product related measurement methods indicate a lower level of FSMS performance, whereas food safety climate was perceived to be on a high level by staff and location responsible (85.2 and 85.8%, Table 5.3). Both the location responsible and staff in restaurant H seem to be unaware of the fact that there are potential food safety and hygiene issues in their location. This is also illustrated by the fact that a score of 1 (and even 0) was repeatedly attributed in restaurant H to several internal audit indicators (e.g. I6, I26). Also the responses for food safety climate component 'risk awareness' were rather high (mode of 4 'Agree' or 5 'Totally agree' for all risk awareness indicators). The discrepancy between the lower measured performance in the techno-managerial route and the higher perceived human route, is a potential dangerous situation to guantee food safety and hygiene.

A similar pattern is seen for restaurant E. Although restaurant E has a the second highest percentage of non-conformities (6.42%), and their internal audit score was second lowest (52), staff and location responsible perceived their food safety climate respectively as highest (87.5%) and moderate (53.6%) (see Table 5.4). This situation was also noticed in the study described in chapter 3 of this doctoral dissertation. Generally, employees in the investigated farm butcheries appeared to perceive their food safety climate to be on a high level, whilst the level of food safety and hygiene, assessed through product and environmental sampling, was rather low. So in both situations (farm butcheries in chapter 3 and restaurants E and H in the current chapter) the potential hazard op optimistic bias and complacency among employees could exist.

Best performing restaurants F and G with less than 2% reported non-conformities according to registration data (Figure 5.4) also achieved to have high internal audit results (70/78 and 76/78 respectively). Furthermore, food safety climate perceptions by staff were also at a high level (82.8% and 75.5%), which is in line with the system and product related assessment results. However, the location responsible for restaurant F appeared to be more critical (46.5%).

Some divergence between results derived by the two applied system and product related verification methods might be observed as well. For instance, restaurant A had less than 2% reported non-conformities and scored lower on the internal audit (66/78). The lower internal audit score can be explained by the fact that measured core temperatures after regeneration did not reach 75°C and were not followed up by the responsible for regeneration. Other employees, however, did take the correct actions (I4 'measurement core temperatures after regeneration (CCP5)' =2). As such, it is questionable whether CCP5 verification data for restaurant A are representative, which could explain the low non-conformance percentage (1.82%), which was based on (potentially inaccurate) reported registrations. Still, internal audits are only a snapshot in time and registration data can only be representative if filled out correctly (Powell et al., 2013).

Concerning the cafeterias, verification of registrations of CCP monitoring revealed that cafeteria G registered far more non-conformities (6.88%) than the other cafeterias. This is in line with findings of the internal audits as cafeteria G has the lowest total internal audit score (50/78). As food safety climate scores for all cafeterias were perceived to be on a good level (Table 5.3 a, b, c), this suggests that, similar to the situation of restaurants E and H, people in cafeteria G are not aware of the food hygiene issues that may concern the foods they serve and how their behavior and food handling might impact on food hygiene and potentially food safety. Same holds for cafeteria E, where both applied system and product related verification methods revealed diverging results: a quite low internal audit score was reported (51/78) which was not reflected in reported registration data, as Figure 5.4 shows a total percentage of 0.79% non-conformities. This low audit score, which was the second lowest of all studied cafeterias, had many causes. Critical limits of CCPs were not known and employees did not know what to do in case of non-conformities (I26 'actions in case of non-conformity'=0). Thermometers were used incorrectly (I19 'correct use of thermometers' =1), as e.g. instead of measuring the temperature in the core of the product as prescribed in the procedure, personnel measured the in the bottom of the product which was near to the cooling element. This incorrect temperature measurement was reflected in the discrepancy between temperatures measured by the auditor during the internal audit and temperature registrations by the personnel (mainly for CCP7 and CCP5, I8 'measurement core temperatures in hot and cold buffets (CCP7)'= 1 and I4 'measurement core temperatures after regeneration (CCP5)'= 1). Still, it is questionable whether registered temperatures were always correct as discrepancies between measured temperatures by the auditor and registered temperatures were large (I9 'registration core temperatures in hot and cold buffets (CCP7)'= 1 and I5 'registration core temperatures after regeneration (CCP5)'= 1).

Overall, through triangulation of the applied methods, one can collect information about different aspects of the food safety culture within a food company or a food service operation. In general, four possibilities can be deduced. The two system and product related verification methods combined can indicate that the level of FSMS performance is high or low, and food safety climate scores as perceived by staff and their responsibles combined, can be in line with or not in line with the system and product related (techno-managerial) measurement methods. The four possibilities are represented in Table 5.6.

Table 5.6: Overview of the four possible (simplified) combinations if results of the human oriented measurement methods (food safety climate) are considered to be high or low and the system and product related methods are considered to be high or low . H: High score (high level), L: Low score (lower level)

Human	System and product	Interpretation
L	L	FSMS performance is at a rather low level and employees are aware of the fact that there are potential hygiene issues at the location which may impact food safety.
H	H	Perceptions of employees are in line with the more objective FSMS performance assessments and both indicate a high level.
L	H	Employees are critical about the food safety climate at their location, although the system and product related methods indicate a high level of FSMS performance. This could suggest that they strive for continuous improvement.
H	L	Employees might be unaware that there are potentially food hygiene/food safety issues at the location. This could suggest that the hazard of optimistic bias or complacency exists.

The last possiblility in Table 5.6 is the most dangerous one. If system and product related measurement methods indicate a low level of FSMS performance, but employees perceive the climate to be on a high level, employees might overestimate their climate through optimistic bias and complacency ("self-satisfaction especially when accompanied by unawareness of actual dangers or deficiencies" (Signore, 2010)), which can pose a risk for food safety (Griffith, 2000).

Of course, behind the low score for the system and product related measurements in Table 5.6, several combinations can exist, which makes it more complex than the four situations presented in Table 5.6. A case by case interpretation for each organization/location separately is necessary to be able to draw valid conclusions about different food safety culture aspects. Relying on one individual method or technique could lead to wrong conclusions. For example, a low number of reported non-conformities does not necessarily imply that food safety and hygiene performance and food safety culture are at a high level, as employees might not understand the importance of correct monitoring and are not dedicated to performing this well, which might be clarified by insights from e.g. internal audits (e.g. restaurant A). Also, a high food safety climate score does not necessarily mean that food safety culture is at a high level, as the food safety climate self-assessment tool is based on perceptions (e.g. restaurant E), which should, therefore, be complemented by more objective measurement methods. This was also illustrated in chapter 3 of this doctoral dissertation, where food safety climate perceptions of butchery employees were linked to the level of microbiological hygiene and safety assessed through microbiological product and environmental sampling.

Jespersen and Wallace (2017) discuss strengths and weaknesses of different methods used to evaluate food safety culture maturity in five multi-national food companies. This was also investigated for the three methods applied in this study: Verification of monitoring data, internal audits and food safety climate self-assessment tool. The method ‘verification of monitoring data’ has as an advantage that it is virtually unobtrusive and can easily be used for longitudinal analysis (Jespersen & Wallace, 2017). However, the usefulness of the data is highly depending on the accuracy of employees in registering. Still, by combining the monitoring data with internal audit data, (in)accuracy of monitoring might be revealed (e.g. restaurant A and cafeteria E). Internal audits have quite some advantages. The auditor has the ability to follow up and lead in-depth investigations of issues and causes noticed during the audit (Jespersen & Wallace, 2017). Moreover, Powell et al. (2013) state that assessing food-handling practices of staff through observations, can provide information about an organization’s food safety culture. The authors mention also several drawbacks. For example, the quality of the data is highly dependent on skills and experience of the auditor and audits are only a snapshot in time (Powell et al., 2013). However, the latter drawback might be mitigated by verification of monitoring data, as this allows to collect data over a longer period of time. As the latter two methods are mainly system and product related, we are still missing the ‘human aspect’ -although through contact with employees some human aspects may already be captured during internal audits - which is essential in food safety culture research. Self-assessment scales are simple and straightforward ways to gather information from a large number of respondents and allow maintaining respondent anonymity (Sallis & Saelens, 2000). However, individual characteristics of respondents (e.g. humans’ tendency to answer socially desirable (Jespersen, MacLaurin, et al., 2017)) can affect the data and lead to less valid responses and a possible gap can exist between self-reported responses and actual beliefs, attitudes and behavior (Barker, Fong, Grossman, Quin, & Reid, 1994). Moreover, low response rates make it difficult to generalize the data (Baruch & Holtom, 2008). By triangulation of these three assessment methods an enriched view on different aspects of food safety culture can be realized. Moreover, besides this multi-method approach, also a ‘multi-source’ approach was applied, as perceptions of both staff and location responsibles could be investigated and compared. This could provide valuable information concerning the alignment between supervisor-subordinate perceptions.

A potential limitation in this study could be the fact that the three applied methods were not executed at the same time, as this was practically not feasible. Still, no major changes in policy, work methodology or management happened during this period, as such, this should not have a major impact on the results. Still, the fact that the internal audits were performed before the food safety climate perceptions were assessed, might result in higher food safety climate scores, as this could result in employees perceiving food safety to be more important at their location than before the audit.

5.5 Conclusion

This chapter illustrates the advantages and added value of applying method triangulation to allow a more comprehensive evaluation of food safety culture, covering both the techno-managerial and human route as illustrated in the food safety culture conceptual model (Figure 1.3). The case study, described in this chapter, illustrated how single-method derived results could lead to wrong conclusions because of the weaknesses of the particular method at hand. By combining food safety/hygiene performance assessment methods different aspects of food safety culture could be investigated and weaknesses of one method can be mitigated by strengths of other methods.

Important to note is that none of the used methods (number of reported non-conformities based on registration of CCP monitoring, internal audit results and food safety climate self-assessment), are considered to have a one on one relation with the number of foodborne illnesses, as, for example, each exceedance of the maximum threshold temperature for refrigerated products will not immediately result in foodborne illness. But this situation is violating the rules and procedures on proper food hygiene and may potentially lead to growth of pathogens and endanger food safety.

Still, valuable information can be gained. Verification of CCP monitoring registrations and internal audits can provide organizations with information about e.g. employee compliance with procedures, problems related to infrastructure, equipment and work methodology. By assessing the food safety climate, insights can be gained about perceived leadership, communication, availability of resources, commitment and risk awareness from both staff’s and responsibles’ points of view.

Moreover, organizations/locations/departments in which the hazard of optimistic bias and complacency may lurk, can be identified as well. And, although this does not allow to predict foodborne illness, which was not the goal of this study, each of the studied variables, methods and techniques have already been proven to enable or hinder organizations in reaching a high and stable level of food safety and hygiene (e.g. Griffith et al. (2010a); Griffith et al. (2010b)). Practically, for these types of organizations, with a central management and food service operations spread over different locations, this case study demonstrates how information gained at the different locations through triangulation of assessment methods can contribute to develop more tailored and location specific strategies for food safety (and food hygiene) improvement, as these can be tailored to the needs, deduced from the different assessments (e.g. infrastructural, increasing awareness,…).

Chapter 6

Towards an extended food safety culture model: studying the moderating role of burnout and jobstress, the mediating role of food safety knowledge and motivation in the relation between food safety climate and food safety behavior

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Abstract

In previous chapters, food safety culture and climate were studied at an organizational level, focusing on the organization as a whole. As the third objective of this doctoral dissertation was to 'study food safety climate at the level of the individual', the focus was shifted to the individual employee, investigating the mechanism by which food safety climate influences individual employees to adopt certain food safety behaviors. Therefore, the conceptual food safety culture model as described in section 1.4.2 was expanded by introducing food safety behavior (composed of food safety compliance and participation, which represent obligated food safety related activities and the achievement of additional voluntary food safety related activities), knowledge, motivation, burnout and jobstress of the individual employees in the organization.

In the present study the relationship between food safety climate and food safety behavior was investigated. Food safety knowledge and motivation were proposed as mediators, explaining the relationship between climate and behavior. Additionally, jobstress and burnout were proposed as moderators, influencing the strength of this relationship. This conceptual model was tested through statistical analysis with data (n=85) collected from two Belgian vegetable processing companies through self-assessment surveys.

A positive relationship between food safety climate and employees' behavior was found. Mediation analysis showed that knowledge is a partial mediator between food safety climate and compliance, participation and behavior, which means that knowledge cannot fully explain this relationship. Motivation is a partial mediator between food safety climate and compliance and behavior only. The moderation effect between jobstress and burnout was not confirmed. These results demonstrate the direct (without mediation) and indirect effect (through motivation and knowledge) of food safety climate on employees' behavior and illustrate the key role of employees' behavior and well-being for governing food safety in a company. This study suggests that human factors might impact the implementation and follow-up of a food safety management system and recommends a more human behavioral approach for the food safety management in food companies.

6.1 Introduction

In chapters 3, 4 and 5 food safety culture and climate were studied at an organizational level, focusing on the organization as a whole. In this chapter, in view of the third objective 'to study food safety climate at the level of the individual', the focus is shifted from the organization as a whole, to the individual employee and the impact of individual characteristics on food safety behavior.

The five keys to safer food - keep clean; separate raw and cooked; cook thoroughly; keep food at safe temperatures; and use safe water and raw materials - established by the World Health Organization (WHO), often involve human errors and incompliance with good working practices and procedures (Greig, Todd, Bartleson, & Michaels, 2007; Powell et al., 2011). Both operators in food companies and consumers at home share responsibilities in these errors and incompliances. Food safety behavior of consumers has already been extensively discussed in scientific literature (e.g. Anderson, Shuster, Hansen, Levy, and Volk (2004) and Fischer et al. (2007)). However, recent studies also highlighted the importance of food safety behavior (e.g. decision making and execution of procedures) of employees working in food processing companies (e.g. Verhoef et al. (2013)).

As explained and illustrated in the previous chapters human behavior of all employees, regardless of their hierarchical position in the company, is believed to be influenced by the food safety climate prevailing in the company. In section 1.4.2 the food safety culture conceptual model was proposed, defined as the interplay of the food safety climate as perceived by employees and management at all levels of a company (so called 'human route') and the implemented FSMS, which will be influenced by the available technology, company characteristics and the context of the company (so called 'techno-managerial route'), resulting in a certain level of food safety and hygiene of the final food products.

The mechanisms and relationships of the 'techno-managerial route' are already widely proven in literature (Luning et al., 2015; Luning, Marcelis, et al., 2011b), providing evidence that the FSMS should be adapted to the risk level of the context and characteristics of a food company in order to be able to reach a satisfying safety, hygiene or quality level of processed foods. However, in previous chapters it was already suggested that not only technological and managerial factors can influence the hygiene and food safety output of an organization, but also 'the human route' should be considered, introducing food safety climate, defined in section 1.4.2 as employees' (shared) perception of leadership, communication, commitment, resources and risk awareness concerning food safety and hygiene within their current work organization.

By means of the food safety climate self-assessment tool, as described in chapter 2, food safety culture's human route was investigated within the organization as a whole, but the human route was not explored on an individual level. This level is important as several studies stress the importance of the individual in an organization or company, as it is the behavior of individual employees which will determine in the end whether procedures are followed and correct decisions (in a food safety/hygiene perspective) are made (Pacholewicz et al., 2016; Wright et al., 2012). As illustrated in section 1.2 and Tables 1.3a-c, several food safety problems and incidents are attributed to practices, attitudes or behavior of employees. Most of these are dealing with transmission of pathogens by food operators (e.g. Holman et al. (2014); Robesyn et al. (2009) and Gallina et al. (2013)), but also chemical problems (e.g. excessive presence of contaminants such as the (possible) human carcinogens acrylamide, furan and monochloropropanediol (MCPD)) were described (e.g. Sanny et al. (2013) and Sanny et al. (2012)). The development of these process contaminants are inherent in certain processes in the food industry. However, concentrations are variable depending, among others, on process settings which are controlled by employees on the workfloor. Therefore, this can be influenced by human behavior and practices.

Because of the essential role of the individual, the conceptual model as described in section 1.4.2 was expanded in this chapter, introducing the individual level of the human route instead of the studying the organization as a whole. The relationship between food safety climate and food safety behavior of employees is investigated by means of three research questions (vide infra) which are tested through data obtained from two vegetable processing companies in Belgium, which are family-based SMEs operating in a similar production context (e.g. similar raw material, legislative framework, size and nature of the company etc.).

6.2 Individual level of the food safety culture conceptual model

Based on literature search and expert discussions between the Department of Food Technology, Safety and Health and the Department of Personnel management, Work and Organizational Psychology (Ghent University), the food safety culture model presented in section 1.4.2 was extended, introducing new variables and relationships establishing the individual human route. Figure 6.1 gives a schematic overview of the extended food safety culture model and our research questions.

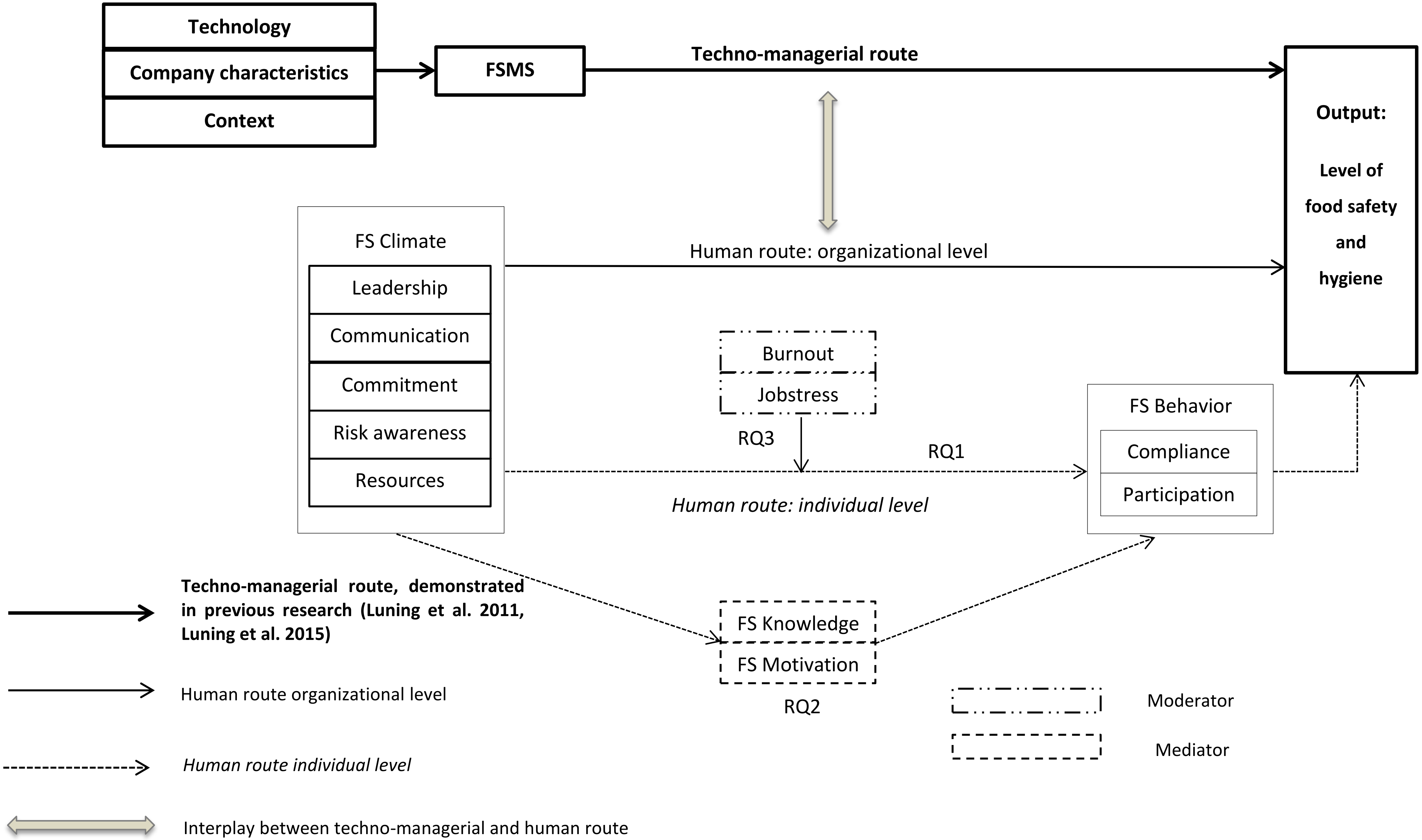

Figure 6.1: Food safety culture extended conceptual model (RQ = research question; FS =food safety)

The new variables and relationships in this conceptual model were, among others, inspired by the model in an occupational safety context proposed by Christian, Bradley, Wallace, and Burke (2009), which is based on the model of Neal and Griffin (2004). In this model safety behavior is considered twofold: on one hand 'safety compliance' is considered, being the execution of the obligated safety related activities (e.g. following of procedures and use of protective clothing), on the other hand 'safety participation' is proposed, being the execution of voluntary safety related activities (e.g. assisting colleagues to make sure they can work in a safe way). This idea was also followed in our research by introducing food safety compliance and food safety participation as components of the food safety behavior of the individual employee. Inspired by previous research in non-food contexts, demonstrating the positive influence of employees' climate perceptions on human behavior (e.g. Neal and Griffin (2006)), research question 1 was proposed: 'Is there a positive relationship between the food safety climate and the food safety behavior (compliance and participation) of the individual employees?' (Figure 6.1: RQ1).

Christian et al. (2009) also proposed that organizational safety climate has an influence on employees' safety motivation and safety knowledge. The authors posit that positive climates enhance safety knowledge because of the reflective nature of environments where safety performance information is transferred both formally (e.g. through meetings, training) and informally (e.g. through on-the-job discussion) and also result in the motivational desire of employees to reciprocate managers' safety actions. Safety motivation concerns the willingness of the individual to make efforts related to safety related activities (e.g. following of procedures). Safety knowledge is dealing with and knowing how to execute certain activities in a safe manner. According to this model safety knowledge and safety motivation are mediators in the relationship between safety climate and employees' safety behavior. Baron and Kenny (1986) stated that mediators are variables which explain the relationship between two other variables. This means that safety climate directly influences safety knowledge/safety motivation, which in turn directly influence safety behavior. However, the relationship between safety climate and safety behavior is indirect. As such, food safety motivation and food safety knowledge were introduced in our current model as human-related explanatory variables between food safety climate and food safety behavior. Accordingly, research question 2 was formulated: 'Is the relationship between food safety climate and food safety behavior explained by food safety knowledge (food safety knowledge as a mediator)?' and 'is the relationship between food safety climate and food safety behavior explained by food safety motivation (food safety motivation as a mediator)?' (RQ2 in Figure 6.1).

Next to the extension the food safety culture model (section 1.4.2) with a motivational variable (i.e. safety motivation) and a cognitive variable (i.e. safety knowledge), jobstress and burnout were introduced as indicators of employees' psychosocial well-being in the new model. Indeed, previous research in non-food organizations revealed that outcomes of safety climate are influenced by boundary conditions such as employees' jobstress due to work conditions or a felt psychological imbalance between employees' work efforts and rewards received at work (Idris & Dollard, 2011) on the one hand and employees' affective or emotional well-being (e.g. burnout) on the other hand (Idris, Dollard, & Yulita, 2014). Jobstress and burnout were both also identified as key human factors influencing patient safety in occupational health contexts (Halbesleben, Wakefield, Wakefield, & Cooper, 2008; Laschinger & Leiter, 2006; Nahrgang, Morgeson, & Hofmann, 2011; Teng, Shyu, Chiou, Fan, & Lam, 2010). Maslach, Schaufeli, and Leiter (2001) define job burnout as: "a prolonged response to chronic emotional and interpersonal stressors on the job, and is defined by the three dimensions of exhaustion, cynicism (distant attitude towards the job), and reduced professional efficacy"(p. 397). This definition can be applied to all sectors, although more research has been done dealing with burnout in health care and the educational sector. However, the existence of these phenomena in food industry cannot be denied, as, among others, Arandjelovic, Ilic, and Jovic (2010) reported high levels of burnout among manufacturing workers in Serbian food industry. Additionally, Zopiatis and Orphanides (2009) mentioned that one in three employees in the food and beverage industry experience high levels of occupational burnout. The general importance (broader than only health care) of burnout and jobstress can also be demonstrated by considering the preliminary results of the European Working Conditions Survey of 2015, collected among 43000 randomly selected employees, comprising a cross-section of society (EurWork, 2015). This survey provided evidence that one third of European employees are perceiving high work demands and work intensity (i.e. effort a person has to make to carry out the job in terms of volume, speed and nature). Furthermore, more than one quarter of the employees reported high emotional demands such as hiding/suppressing feelings in the work place. Both factors are considered as psychosocial risk factors which can result in increased levels of stress and burnout.

Therefore and based on expert discussions, jobstress and burnout were introduced as potential moderators in the relationship between food safety climate and food safety behavior. Moderators are variables which influence the strength (weaken or strengthen) of the relationship between two other variables (Baron & Kenny, 1986). This means that the presumed positive relationship between food safety climate and food safety behavior can be influenced by different levels of jobstress and burnout. For example, the positive relationship between food safety climate and food safety behavior would be weakened or become non-existing among employees who experience high jobstress or burnout at work. This brings us to the third research question: 'Is the strength of the positive relationship between food safety climate and food safety behavior influenced by burnout

(burnout as a moderator)?’ and ‘is the strength of the positive relationship between food safety climate and food safety behavior influenced by job stress (jobstress as a moderator)?’ (RQ3 in Figure 6.1). Each of the three mentioned research questions were investigated specifically with regard to food safety compliance and food safety participation, but also generically for food safety behavior as a whole.

6.3 Assessment of variables in the extended food safety culture model

The food safety climate self-assessment survey, which was developed in chapter 2, was further complemented with well-described items in scientific literature on safety behavior, knowledge, motivation, burnout and jobstress. Each of them were already applied and validated in safety areas, mostly outside food safety. A self-assessment survey was constructed, allowing the assessment of the study variables (complete survey: Appendix 6.A).

6.3.1 Food safety climate

For the measurement of the food safety climate as perceived by the employees, the 28 indicators of the food safety climate assessment tool were used. The development and validation of this tool are described in chapter 2. Every item is a statement at which each respondent can answer by means of a five-point Likert answer scale (1 → 5: totally disagree → totally agree). This tool also allows the measurement of the five components of food safety climate as defined in chapter 2 : leadership (6 items), communication (5 items), commitment (6 items), resources (6 items) and risk awareness (5 items). Both for the components and for the total food safety climate, scores were summed in order to have a total score per component and a total food safety climate score. Internal consistencies (Cronbach’s α) of the component scales and the total food safety climate scale were respectively: 0.89, 0.84, 0.88, 0.88, 0.87 and 0.97 (IBM SPSS version 23 - Chicago, Illinois).

6.3.2 Food safety behavior

Food safety behavior was measured with eight items. Four items were dealing with food safety compliance (i.e. the extent to which food safety related behavioral rules are followed) and four items with food safety participation (i.e. the extent to which employees participate voluntary in food safety related matters in the organization). For food safety compliance, all four items of the ‘Safety Compliance Scale’ of Neal et al. (2000) were adapted to a food safety context (e.g. “I follow all the necessary hygiene and food safety procedures, when I carry out my job”). The food safety participation scale was developed by adapting all four items of the ‘Safety Participation Scale’ of Neal et al. (2000) to a food safety context (e.g. “I promote a hygienic and food safe way of working in my workplace”). Respondents could answer using a five-point Likert answer scale (1 → 5: totally disagree → totally agree). Total scores for food safety behavior as a whole and for both components compliance and participation were calculated by adding up the scores for the different items. Internal consistencies were respectively: 0.94, 0.94 and 0.90.

6.3.3 Food safety knowledge

Food safety knowledge was measured with all four items of the 'Safety Knowledge Scale' of Neal and Griffin (2006) after adapting them to a food safety context (e.g. "I know how to perform my job in a food safe and hygienic manner"). Respondents could answer using a five-point Likert answer scale (1 → 5: totally disagree → totally agree). The total food safety knowledge score was calculated by adding up the scores for the different items. Internal consistency for this scale was 0.88.

6.3.4 Food safety motivation

Food safety motivation was measured with all four items of the 'Safety Motivation Scale' of Neal et al. (2000) after adapting them to a food safety context (e.g. "I believe that workplace hygiene and food safety are important issues"). Respondents could answer using a five-point Likert answer scale (1 → 5: totally disagree → totally agree). The total food safety motivation score was calculated by adding up the scores for the different items. Internal consistency for this scale was 0.89.

6.3.5 Burnout

Burnout was measured with all 15 items of the 'Utrechtse Burnout Schaal' (UBOS) of Schaufeli and Van Dierendonck (2000) (e.g. "I feel mentally exhausted by my job"). Respondents could answer using a seven-point answer scale from 'never' (score 1) to 'always (daily)' (score 7). In line with the guidelines of De Hoogh and Den Hartog (2009), an overall burnout score was calculated. The internal consistency of this scale was 0.88.

6.3.6 Jobstress

Jobstress was measured with a validated single item based on the research of Coetsier et al. (1996) (i.e. "How often do you feel stressed because of your job?"). Respondents could answer using a seven-point answer scale from 'never' (score 1) to 'always (daily)' (score 7).

6.3.7 Control variables

Variables which are related to the dependent variable, but are not in the scope of the study, can be introduced as control variables in the regression. As such their effects are removed from the equation. Selection of control variables was executed by listing up the variables proven to be related to behavior in scientific research in an occupational health context (e.g. Lievens and Vlerick (2014)), followed by expert discussions between the Department of Food Technology, Safety and Health and the Department of Personnel management, Work and Organizational Psychology (Ghent University) in order to retain the relevant variables and avoid statistical overcorrection.

Demographical characteristics

In order to avoid statistical overcorrection only two demographical characteristics ('gender' and 'seniority in the food sector') were included in the regression analysis. Furthermore, Fatimah et al. (2014) reported significantly different perceptions of food safety culture depending on gender and seniority.

Conscientiousness

Conscientiousness is often added as a control variable by researchers in work psychology (e.g. Lievens and Vlerick (2014)), as this variable has been proven to be an important indicator of performance in the workplace (Walumbwa & Schaubroeck, 2009) and as this variable was not the primary interest in this study.

Five items from the total of 13 items of the 'Conscientiousness Scale' of the 'International Personality Item Pool'(IPIP, 2001) were selected by experts from the Department of Personnel management, Work and Organizational Psychology (Ghent University) assessing conscientiousness (e.g. "I pay attention to details"). Respondents could answer using a five-point Likert answer scale (1 → 5: totally disagree → totally agree). The total conscientiousness score was calculated by adding up the scores for the different items. The internal consistency of this scale was 0.73.

Company characteristics

In order to increase the sample size, data of the two participating vegetable processing companies were pooled for statistical analysis. Accordingly, company (1 or 2) was included as a control variable. As the employees of company 2 were primarily foreign (Romanian or Polish) and employed through a temporarily contract, whereas in company 1 employees were mainly Belgian and employed through a permanent contract, including company as a control variable could also cover potential effects of nationality and contract type, as this study was not aiming to investigate these factors specifically. However, it should be noted that several authors point out the potential influence of national culture on an organization's food safety culture (Nyarugwe et al., 2016; Taylor, 2011). Inclusion of company as a control variable can also be justified because both the reported food safety climate and food safety behavior were significantly different between company 1 and 2 ($p < 0.001$ and $p = 0.019$, respectively).

6.4 Data collection and ethical considerations

6.4.1 Data collection

In order to test the proposed model, data were collected from employees from different food processing companies. Two Belgian vegetable processing companies were selected to participate in the data collection because of their similar risk context in raw materials and processes, organizational characteristics and chain characteristics. Both companies had similar activities (cutting, washing and packaging of fresh ready-to-eat vegetables), a similar number of employees (n = 85 and n = 90) and a HACCP based food safety management system with certification for IFS (IFS, 2014) and the Belgian self-checking system (certified by and independent certification body). Moreover, they are both SMEs, with family based ownership. One difference was that in company 1 mainly Belgian employees with fixed contracts were employed and in company 2 mainly foreign (Romanian and Polish) employees with temporary contracts. As such the survey was translated in Dutch, Romanian, Polish and English. First the survey was presented to the company owner(s) and quality responsible of each company, in order to obtain their approval for participation in our study. After approval, the surveys were distributed in the company in paper format in a closed envelope. This envelope also contained a stamped and addressed answer envelope and an accompanying letter which explained the scientific purposes of the survey and guaranteed employees' anonymity. The employees of both companies could send the filled out survey directly to the Department of Food Safety and Food Quality, Ghent University, in the answer envelope. As company 2 was working especially with foreign employees with a temporary contract, the interim office helped with data collection. After the first distribution of the survey, two reminders and motivation actions were organized, for which company owner(s) and/or quality responsible (and interim office employees) directly addressed their employees to motivate them to cooperate in the study. For the second motivation action candy was distributed as an incentive. The response rate in company 1 was 60%, with 5.6% of the responses collected from supervisors/leaders and 94.4% from operators, for company 2 this was 36%, with 30% of the responses collected from supervisors/leaders and 70% from operators. So, in total 85 responses were collected from both companies. For statistical analysis data of company 1 and company 2 were pooled, but the employment in a particular company was incorporated as a control variable (see above).

6.4.2 Ethical considerations

This study was discussed with and approved by the management of both companies. A cover letter was attached to the survey, explaining the purpose of the study and stating that results would be used in scientific publications and a doctoral dissertation. Return of a completed questionnaire was considered as a consent to participate. Participants were informed by the researchers that participation was not mandatory and that anonymity was guaranteed.

6.5 Statistical data processing

For all statistical analyses IBM SPSS Statistics version 23 (Chicago, Illinois) was used. In order to gain a first insight in the obtained data, Pearson correlations and internal consistencies were calculated for all continuous variables. For the variables gender (male/female) and company (company 1 or 2) t – tests were executed, as these variables are non-continuous. Based on these correlations RQ1 could be investigated.

For RQ2 (mediation of knowledge and motivation) the multiregression procedure of Baron and Kenny (1986) was used. This method consists of three regression phases. In a first phase the relationship between the independent variable (food safety climate) and the dependent variable (compliance/participation/behavior) was investigated, taking into account the control variables. This regression was executed three times: once with compliance as dependent variable, once with participation as dependent variable and once with behavior as dependent variable. Mathematically this could be written as follows: $DV = \beta_1 CV_1 + \beta_2 CV_2 + \beta_3 CV_3 + \beta_4 CV_4 + \beta_5 IV$ (with DV: dependent variable; β: regression coefficient; CV: control variable and IV: independent variable). Each regression was executed in two steps. First only the control variables were inserted as terms to explain the dependent variable, in the second step food safety climate was added as independent variable.

In the second phase of Baron and Kenny (1986) procedure, it was tested whether the independent variable (food safety climate) was related to the mediator (knowledge/motivation), taking into account the control variables (gender, conscientiousness, seniority in sector, and company). Mathematically this regression was presented as follows: $Me = \beta_1 CV_1 + \beta_2 CV_2 + \beta_3 CV_3 + \beta_4 CV_4 + \beta_5 IV$ with Me = mediator (knowledge or motivation), CV = control variable and IV = independent variable. In a first step only the control variables were inserted as predictors in this equation and in the second step food safety climate was added as independent variable.

In the third and final phase of Baron and Kenny (1986) procedure, the relationship between the mediator (knowledge/motivation) and the dependent variable (compliance/participation/behavior) was checked, controlling for the control variables and also for the independent variable (food safety climate), as for total mediation the relationship between the mediator and the dependent variable should be present, irrespective of the independent variable. In total 6 regressions were executed, one time for every combination mediator-dependent variable. Mathematically the regression could be presented as follows: $DV = \beta_1 CV_1 + \beta_2 CV_2 + \beta_3 CV_3 + \beta_4 CV_4 + \beta_5 IV + \beta_6 Me$ with DV = dependent variable, CV = control variable, IV = independent variable and Me = Mediator. In a first step control variables were added as terms in this equation, in a second step also food safety climate was added and in the third step the mediator (once for knowledge and once for motivation) was added.

RQ3 (moderation of burnout and jobstress) was investigated using regression analysis. Before the regression the independent variable food safety climate and the moderators burnout and jobstress were centralized (subtraction of mean value) in order to make β-values more interpretable. The mathematical equation for this regression was the following: $DV = \beta_1 CV_1 + \beta_2 CV_2 + \beta_3 CV_3 + \beta_4 CV_4 + \beta_5 IV + \beta_6 Mo + \beta_7 IVMo$ with DV = dependent variable, CV = control variable, IV = independent variable and Mo = moderator (burnout or jobstress). As such, the total effect of the independent variable on the dependent variable was equal to $\beta_5 + \beta_7 Mo$. The first term presented the main effect of the independent variable and the second term was originating from the interaction of the independent variable and the moderator. If this interaction term was significant, this means that the strength of the effect of the independent variable on the dependent variable was influenced by the moderator variable and that moderation can indeed be assumed (Dawson, 2014). In total six regressions were performed for each combination moderator-dependent variable. In the first step only the control variables were added in the equation, in the second step also the independent variable (food safety climate) and the moderator variable (burnout or jobstress) was added. In the third step of the regression the interaction term (multiplication of IV (independent variable) and MO (moderator)) was added.

Additionally, a bootstrapping method (Process 2.10 software; (Hayes, 2013)) was applied (5000 bootstrapped samples) to confirm the results obtained by regression analysis (RQ2 and RQ3). A 95% confidence interval was calculated and reported for the effects. Missing values were replaced by the mean of the responses which were filled out of the subscale, if at least half of the questions of the subscale were filled out. Before the replacement of the missing values the Little's MCAR (Missing Completely At Random) test was executed for the different variables (with missing values). For all of the variables this test showed that missing values were completely at random and not systematic for certain items/questions ($p > 0.05$).

6.6 Investigation of the research questions

6.6.1 Relation between food safety climate and food safety behavior (RQ1)

In order to investigate the relationship between the food safety climate and the food safety behavior (compliance and participation) of the individual employees first an overview table of the correlations between the different variables was made (Table 6.1).

Table 6.1 presents the internal consistencies (on the diagonal) and the correlations (beneath the diagonal) of all the studied variables. It can be derived that seniority in the sector is significantly positively correlated with the dependent variables participation and behavior (r = 0.26 and 0.25), but not significantly with compliance (r = 0.20). Conscientiousness is significantly positively correlated with all three dependent variables (compliance, participation and behavior, r = 0.71, 0.65 and 0.73, respectively). Based on these correlations it seems relevant to incorporate both seniority in the food sector and conscientiousness as control variables in the model.

T-tests for gender and company showed that there is no significant difference in variable 'participation' between company 1 and company 2 (p = 0.123), but for 'compliance' and 'behavior' this difference is significant (p = 0.006 and 0.019). As such 'company' is incorporated as a control variable in the model. Although no significant differences were seen for all dependent variables between men and women, gender was still included as a control variable in line with previous safety research (Lievens & Vlerick, 2014).

Considering research question 1: 'Is there a positive relationship between the food safety climate and the food safety behavior (compliance and participation) of the individual employees', Table 6.1 shows that independent variable food safety climate is significantly positively correlated with all dependent variables (compliance, participation and behavior, r = 0.71, 0.68 and 0.75). This means that the better employees perceive the food safety climate in their company, the more they report behaving in a good food safety way or vice versa.

Table 6.1: Pearson correlations (r, beneath diagonal) and internal consistencies (α, on the diagonal) of the study variables regarding the human route at individual level in the food safety culture of a food business (n = 85)

Variable	1	2	3	4	5	6	7	8	9	10
1.Seniority	(-)									
2. Conscientiousness	0.26*	(0.73)								
3. Food safety climate	0.26*	0.65**	(0.97)							
4. Knowledge	0.28*	0.60**	0.63**	(0.88)						
5. Motivation	0.31**	0.70**	0.64**	0.72**	(0.89)					
6. Burnout	-0.28*	-0.54**	-0.49**	-0.42**	-0.49**	(0.88)				
7. Jobstress	-0.14	-0.27*	-0.28*	-0.09	-0.21	0.59**	(-)			
8. Compliance	0.20	0.71**	0.71**	0.78**	0.75**	-0.41**	-0.21	(0.94)		
9. Participation	0.26*	0.65**	0.68**	0.65**	0.65**	-0.52**	-0.31**	0.71**	(0.90)	
10. Behavior	0.25*	0.73**	0.75**	0.77**	0.76**	-0.50**	-0.28*	0.93**	0.92**	(0.94)

* $p < 0.05$; ** $p < 0.01$

6.6.2 Mediation of food safety motivation and food safety knowledge (RQ2)

In order to investigate mediation, the multi-regression procedure of Baron and Kenny (1986) was used (vide supra).

First regression

The first regression investigated the positive relationship between food safety climate and compliance, participation and behavior as a whole. Table 6.2 (regression 1) shows that the control variables were statistically significantly related to compliance, participation and behavior as a whole ($F(4,74) = 22.05, 15.50, 24.83$, respectively for compliance, participation and behavior, and $p < 0.001$), which could be expected based on the investigated correlations (Table 6.1). Additionally, food safety climate as independent variable was also significantly related to all three dependent variables ($F(1,73) = 18.06, 23.12, 31.16$, respectively for compliance, participation and behavior and $p < 0.001$). Food safety climate explained 9.0% incremental variance in food safety compliance, 13.1% in participation and 12.8% in behavior. This means that high reported scores on food safety climate were associated with high food safety compliance, participation and behavior scores (positive values for β_5 in Table 6.2 (regression 1): 0.432, 0.520, 0.514 with $p < 0.001$), even after taking control variables into account. This is in line with the strong correlations between food safety climate and compliance, participation and behavior ($r = 0.71, 0.68, 0.75$, respectively) in Table 6.1. As such it can be concluded that a strong positive relationship was found between food safety climate on the one hand and compliance, participation and behavior on the other hand, irrespective of employees' gender, seniority, conscientiousness and company (research question 1).

Second regression

The second regression investigated whether food safety climate was related to the proposed mediators (knowledge and motivation). Table 6.2 (regression 2) provides evidence that the control variables were statistically significantly related to food safety knowledge and motivation ($F(4,74) = 12.64, 20.68$ and $p < 0.001$). Adding food safety climate as a variable in the equation is significant both for knowledge and motivation ($F(1,73) = 14.59, 15.09$ and $p < 0.001$). This results in 9.9% incremental variance explained in the variable knowledge and 8.1% incremental variance explained in the variable motivation, irrespective of the variance explained by the control variables. From the positive values of β_5 in Table 6.2 (regression 2) ($\beta_{5:}$ 0.452, 0.409 and with $p < 0.001$) it can be concluded that the more employees perceive the food safety climate in their work environment as positive, the more food safety knowledge and motivation they report.

Table 6.2: Hierarchical regression of variables compliance, participation and behavior on the included control variables and on food safety climate (regression 1 of mediation, research question 1 and 2) and hierarchical regression of food safety knowledge and motivation on the included control variables and on food safety climate (regression 2 of mediation, research question 2).

Regression 1 of mediation							
		Compliance		**Participation**		**Behavior**	
Terms in the equation		**Step 1**	**Step 2**	**Step 1**	**Step 2**	**Step 1**	**Step 2**
Control variables:							
- Company	β_1	-0.049	0.083	0.135	0.295**	0.045	0.203*
- Gender	β_2	-0.048	-0.042	0.057	0.064	0.004	0.011
- Seniority	β_3	-0.002	0.024	0.148	0.178*	0.078	0.108
- Conscientiousness	β_4	0.722**	0.477**	0.667**	0.373**	0.751**	0.460**
Food safety climate	β_5		0.432**		0.520**		0.514**
	R^2	0.544**	0.634**	0.456**	0.587**	0.573**	0.701**
	Adjusted R^2	0.519**	0.609**	0.427**	0.558**	0.550**	0.680**
	ΔR^2	0.544**	0.090**	0.456**	0.131**	0.573**	0.128**

Regression 2 of mediation					
		Knowledge		**Motivation**	
Terms in the equation		**Step 1**	**Step 2**	**Step 1**	**Step 2**
Control variables:					
- Company	β_1	0.023	0.162	0.081	0.207*
- Gender	β_2	-0.139	-0.132	0.021	0.027
- Seniority	β_3	0.129	0.156	0.179	0.203*
- Conscientiousness	β_4	0.601**	0.345**	0.692**	0.461**
Food safety climate	β_5		0.452**		0.409**
	R^2	0.406**	0.505**	0.528**	0.609**
	Adjusted R^2	0.374**	0.471**	0.502**	0.582**
	ΔR^2	0.406**	0.099**	0.528**	0.081**

* $p < 0.05$; ** $p < 0.01$; Company coded as 1 or 2

Third regression

The third regression investigated whether the mediators (knowledge and motivation) were associated with each of the dependent variables (compliance, participation and behavior). Table 6.3 shows that knowledge was significantly related to all three dependent variables, being compliance, participation and behavior ($F(1,72) = 29.68$ (compliance), 4.90 (participation), 22.18 (behavior) and $p < 0.001$, $p = 0.030$, $p < 0.001$ respectively). Knowledge explained 10.7% incremental variance in compliance, 2.6% in participation and 7.0% in behavior, irrespective of the variance already explained by the control variables and by the food safety climate. The positive and significant $ß_6$-values in Table 6.3 (0.464 (compliance), 0.231 (participation), 0.377 (behavior) with $p < 0.001$, $p = 0.030$, $p < 0.001$) suggested that an increase in food safety knowledge was associated with an increase in food safety compliance, participation and behavior as a whole.

Adding motivation (Table 6.3) showed a significant association with both compliance and behavior ($F(1,72) = 13.28$, 10.48 with $p = 0.001$ and 0.002 respectively), but not for participation ($F(1,72) = 2.63$ and $p = 0.109$). An incremental variance of 5.7% was explained by compliance and 3.8% by behavior, irrespective of the variance already explained by the control variables and by food safety climate. In Table 6.3 $ß_6$-values were only significant for compliance and for behavior (0.382, 0.312 and $p = 0.001$, 0.002). These results suggested that an increase in food safety motivation is associated with an increase in food safety compliance and behavior as a whole.

Based on the results of the three regressions described above, one might be tempted to conclude full mediational effects of food safety knowledge and motivation. However, for full mediation, two conditions need to be met in the third phase: firstly, the mediator has to be significantly related to the dependent variable. Secondly, when the mediator is entered in this phase, the significant association between the independent variable and the dependent variable should fade out to a non-significant association. If, however, this second condition is not met and the independent variable remains significantly related to the dependent variable, the mediation is partial. Table 6.3 clearly shows that the indirect effect through both knowledge and motivation was only partial, as after adding the mediators (knowledge or motivation), the direct relationship (without knowledge/motivation as mediators) between food safety climate and the dependent variable remained significant. This was also reflected by the significant $β_5$ -values after including the mediators (for knowledge: 0.222 (compliance), 0.416 (participation) and 0.343 (behavior); for motivation 0.276 (compliance) and 0.386 (behavior)). Even though these $β_5$–values are in absolute terms lowered compared to the $β_5$-values in Table 6.2 (regression 1), food safety knowledge was only a partial mediator between food safety climate and compliance/participation/behavior and food

Table 6.3: Hierarchical regression of compliance, participation and behavior on the included control variables, on food safety climate and on knowledge (Know.) and motivation (Mot.) as mediators (regression 3 of mediation, research question 2)

Terms in the equation		Compliance Step 1	Compliance Step 2	Compliance Step 3 Know.	Compliance Step 3 Mot.	Participation Step 1	Participation Step 2	Participation Step 3 Know.	Participation Step 3 Mot.	Behavior Step 1	Behavior Step 2	Behavior Step 3 Know.	Behavior Step 3 Mot.
Control variables													
- Company	β_1	-0.049	0.083	0.008	0.004	0.135	0.295**	0.258*	0.255*	0.045	0.203*	0.142	0.138
- Gender	β_2	-0.048	-0.042	0.020	-0.052	0.057	0.064	0.095	0.059	0.004	0.011	0.061	0.003
- Seniority	β_3	-0.002	0.024	-0.049	-0.054	0.148	0.178*	0.142	0.139	0.078	0.108	0.049	0.045
- Conscient-iousness.	β_4	0.722**	0.477**	0.317**	0.301**	0.667**	0.373**	0.294**	0.284*	0.751**	0.460**	0.330**	0.316**
Food safety climate	β_5		0.432**	0.222*	0.276**		0.520**	0.416**	0.441**		0.514**	0.343**	0.386**
Knowledge/ motivation	β_6			0.464**	0.382**			0.231*	0.193			0.377**	0.312**
	R^2	0.544**	0.634**	0.741**	0.691**	0.456**	0.587**	0.613*	0.601	0.573**	0.701**	0.771**	0.739**
	Adj R^2	0.519**	0.609**	0.719**	0.665**	0.427**	0.558**	0.581*	0.568	0.550**	0.680**	0.752**	0.717**
	ΔR^2	0.544**	0.090**	0.107**	0.057**	0.456**	0.131**	0.026*	0.015	0.573**	0.128**	0.070**	0.038**

* $p < 0.05$; ** $p < 0.01$; Adj= adjusted; Company coded as 1 or 2

safety motivation was also only a partial mediator between food safety climate and compliance/behavior. This means that knowledge/motivation could not fully explain the relationship between food safety climate and the dependent variables.

These three phases were also investigated by means of the Hayes Process 2.10 software and similar results were obtained. Indeed, indirect effects between food safety climate and compliance/participation/behavior were all significant for knowledge as a mediator (95% confidence intervals did not comprise zero: CI = [0.008-0.064]; [0.0002-0.046] and [0.011-0.107]; z = 0.033, 0.016 and 0.049; SE= 0.014, 0.011 and 0.024, respectively for compliance, participation and behavior). For motivation as a mediator, only the indirect effect of food safety climate on compliance and behavior was significant (95% confidence intervals: CI= [0.007-0.054] and [0.007-0.084]; z = 0.025 and 0.037; SE = 0.011 and 0.019, for compliance and behavior respectively). The indirect effect through motivation on participation was not significant as its 95% confidence interval [(-0.003) - 0.036] (z = 0.012, SE = 0.010) does comprise zero. However, direct effects of food safety climate remained significant for all combinations ($p < 0.05$), which also suggest partial mediation of both mediators.

In the used methodology, mediation of food safety knowledge and food safety motivation was tested by introducing the variables separately. However, as Table 6.1 provides evidence that knowledge and motivation are strongly correlated ($r = 0.72$ and $p < 0.01$), this could influence the results of the mediation analysis. This was investigated using the Hayes Process 2.10 software, by adding both mediators at the same time in the model. As such, separate indirect effects of both mediators could be calculated, while controlling for the other mediator. The same results were obtained as described above.

6.6.3 Moderation of burnout and jobstress (RQ 3)

Results of the regression analysis (methodology: vide supra) are given in Table 6.4. It shows that adding the interaction term (food safety climate x burnout) was insignificant for each of the dependent variables (compliance, participation and behavior: $F(1,71) = 1.51, 1.49, 0.00$ and $p = 0.223, 0.995, 0.400$ respectively). Moreover, the incremental variance in compliance, participation and behavior explained by this multiplicative term was negligible and not significant : 0.8% 0.8% and 0.0% . Also coefficient β_7 was not significant : 0.099, -0.101 and 0.000 respectively. From this, it can be concluded that burnout was not acting as a moderator in the relationship between food safety climate and food safety compliance/participation/behavior.

A similar conclusion can be drawn from Table 6.5 for jobstress as moderator. The addition of the multiplicative term (food safety climate x jobstress) was insignificant for each dependent variable ($F(1,69) = 0.03, 0.71, 0.39$ and $p= 0.227, 0.868, 0.533$).

Table 6.4: Hierarchical regression of compliance, participation and behavior on the included control variables, on food safety climate, on burnout and the interaction of burnout and food safety climate (Research question 3)

		Compliance			Participation			Behavior		
Terms in the equation		**Step 1**	**Step 2**	**Step 3**	**Step 1**	**Step 2**	**Step 3**	**Step 1**	**Step 2**	**Step 3**
Control variables										
- Company	β_1	-0.049	0.080	0.075	0.135	0.310**	0.316**	0.045	0.209*	0.209*
- Gender	β_2	-0.048	-0.049	-0.056	0.057	0.102	0.109	0.004	0.027	0.027
- Seniority	β_3	-0.002	0.027	0.022	0.148	0.162	0.167	0.078	0.101	0.101
- Conscient-iousness	β_4	0.722**	0.492**	0.500**	0.667**	0.299**	0.291**	0.751**	0.429**	0.429**
Food safety climate	β_5		0.441**	0.390**		0.478**	0.530**		0.496**	0.496**
Burnout	β_6		0.041	0.043		-0.199*	-0.202*		-0.083	-0.083
FSclimate*BO	β_7			0.099			-0.101			0.000
	R^2	0.544**	0.635**	0.643	0.456**	0.611**	0.619	0.573**	0.705**	0.705
	Adj R^2	0.519**	0.605**	0.608	0.427**	0.579**	0.582	0.550**	0.681**	0.676
	ΔR^2	0.544**	0.092**	0.008	0.456**	0.156**	0.008	0.573**	0.132**	0.000

* p < 0.05; ** p < 0.01; Adj = adjusted; FS = food safety; BO = burnout ; Company coded as 1 or 2

Table 6.5: Hierarchical regression of compliance, participation and behavior on the included control variables, on food safety climate, on jobstress and the interaction of jobstress and food safety climate (Research question 3)

		Compliance			Participation			Behavior		
Terms in the equation		**Step 1**	**Step 2**	**Step 3**	**Step 1**	**Step 2**	**Step 3**	**Step 1**	**Step 2**	**Step 3**
Controlevariables										
- Company	β_1	-0.064	0.069	0.066	0.129	0.292**	0.276**	0.034	0.193*	0.183*
- Gender	β_2	-0.035	-0.033	-0.034	0.054	0.077	0.072	0.009	0.023	0.020
- Seniority	β_3	0.008	0.042	0.039	0.143	0.166	0.153	0.080	0.111	0.103
- Conscientiousness	β_4	0.725**	0.498**	0.496**	0.661**	0.363**	0.356**	0.749**	0.466**	0.462**
Food safety Climate	β_5		0.434**	0.435**		0.483**	0.486**		0.495**	0.497**
Jobstress	β_6		0.064	0.061		-0.118	-0.138		-0.028	-0.040
FSclimate*JS	β_7			-0.013			-0.070			-0.044
	R^2	0.563**	0.652**	0.652	0.444**	0.586**	0.590	0.577**	0.702**	0.703
	Adj R^2	0.539**	0.623**	0.617	0.413**	0.550**	0.549	0.554**	0.676**	0.673
	ΔR^2	0.563**	0.089**	0.000	0.444**	0.142**	0.004	0.577**	0.125**	0.002

* $p < 0.05$; ** $p < 0.01$; Adj = adjusted; FS = food safety; JS = jobstress; Company coded as 1 or 2

Again incremental variances were negligible (0.0%, 0.4% and 0.2%) and β_7-values were not significant (-0.013, -0.070, -0.044 with p = 0.868, 0.401, 0.533). As such, it can be concluded that jobstress was not acting as a moderator in the relationship between food safety climate and food safety compliance/participation/behavior.

Moderation analyses through the Hayes Process 2.10 software gave similar results and reconfirmed that burnout could not be considered as a moderator between food safety climate and compliance/participation/behavior (β: 0.001 (compliance), -0.001 (participation), 0.000 (behavior) with p= 0.195 (compliance), 0.321 (participation), 1 (behavior)). Also jobstress could not be considered a moderator (β: -0.001, -0006, -0.008 with p= 0.928, 0.569, 0.735 for compliance, participation and behavior respectively).

Assessment of burnout and jobstress data of the vegetable producing companies showed that mean burnout score was rather low (mean of 39.25, with lowest possible value 15 and highest possible value 105) and the mean jobstress score was average (mean of 3.4, with lowest possible value 1 and highest possible value 7).

6.7 Discussion

Previous chapters already demonstrated the importance and relationship of food safety climate and culture on an organizational level. The present work, introducing the individual level of the human route, proposes the mediating role of food safety knowledge and food safety motivation and the moderating role of burnout and jobstress in the relationship between food safety climate and food safety behavior (Figure 6.1). As already mentioned above, food safety behavior is composed of two components in this study: compliance and participation. It should be noted that some authors do not consider voluntary activities (e.g. assisting colleagues) as a component of safety behavior and only include the compliance component (Zhou, Fang, & Wang, 2008). However, in most safety behavior research both components were included separately (e.g. Christian et al. (2009); Lu and Yang (2011); Fugas, Silva, and Melia (2012)). However research questions were in this study also investigated for food safety behavior as a whole (sum of compliance and participation), allowing a more generic measurement of food safety behavior.

Concerning research question 1, it can be stated that, indeed, based on the obtained data a better food safety climate was associated with better food safety behavior of the employees in the organization. This could be expected, and is fully in line with research conducted in non-food contexts, where the relationship between safety climate and safety behavior/safety performance is already widely investigated and confirmed (e.g. Zohar (1980), Hofmann and Stetzer (1996), Neal et al.

(2000)). Moreover, in food contexts nearly all studied food safety climate components (leadership, communication, commitment, resources and risk awareness), were already associated with employees' behavior (e.g. Panisello and Quantick (2001), Yapp and Fairman (2006), Bas, Yuksel, and Cavusoglu (2007)). Furthermore, several authors (Chapman, Eversley, Fillion, Maclaurin, & Powell, 2010; Fatimah et al., 2014; Nyarugwe et al., 2016) acknowledge the positive association between food safety culture as a whole and food safety behavior. This suggests that employees' food safety behavior might shape or influence the food safety climate at work and/or that employees' food safety behavior is at least partly rooted in the perceived organizational food safety climate.

Aiming to deepen our understanding of the positive relationship between food safety climate and food safety behavior, we explored employees' food safety motivation and food safety knowledge as potential explanatory mechanisms or mediators in this relation (research question 2) through the method of Baron and Kenny (1986), as this is the most widely used method for mediation analysis in social and health sciences. However, as this statistical method has been criticized (MacKinnon, Fairchild, & Fritz, 2007), the data regarding the mediation (RQ2) and moderation analysis (RQ3) were additionally analyzed, using a bootstrapping method. Still, the same conclusions could be drawn from both methods. Indeed, results obtained from analysis of the obtained data, showed a direct effect (without mediation of knowledge/motivation) and an indirect effect (through knowledge and motivation as mediators) as well of food safety climate on employees' behavior. Specifically, the analyses showed that for our data, knowledge was a partial mediator between food safety climate and compliance, participation and behavior as a whole. However, motivation was only a partial mediator in the relationship between food safety climate and compliance and behavior.

These results are partly in line with Neal et al. (2000) who investigated similar relations in the health care sector, but only for compliance and participation and not for behavior as a whole. They concluded that 'safety knowledge' is respectively a full or partial mediator between safety climate and compliance and safety climate and participation on the one hand; and 'safety motivation' is respectively a full or partial mediator between safety climate and compliance and between safety climate and participation on the other hand.

Although it was possible in our study to replicate the partial mediational effect of both studied mediators in a food context, no full mediational effects could be proven in the current paper. This could be expected as probably other factors beyond employees' food safety knowledge and motivation, could also be of importance or explaining the relationship between food safety climate and behavior. For instance, it might be that food safety climate has an impact on individual food safety behavior through its impact on social relations or psychological processes within work groups or teams in a food organization (e.g. interactions within a team/ group dynamics (Mitropoulos & Memarian, 2012; Nyarugwe et al., 2016) and increased social pressure (Yeow & Goomas, 2014)). Also the existence of subcultures might have an impact, as Manning (2017) provides evidence that both the overarching food safety culture and the associated subcultures are important in food safety management. Also Fatimah et al. (2014) provide a possible explanation for the partial mediation, as the authors state that sufficient food safety knowledge may not always be in line with an actual behavior in accordance with food safety rules.

Neal et al. (2000) also tested the hypothesis that knowledge has a stronger influence on compliance than on participation, which was confirmed by their results. This can also be seen in the results of our study as in Table 6.3 the β_6–coefficient was higher with regard to compliance (0.464) than for participation (0.231). They also proposed the hypothesis that motivation has a stronger influence on participation than on compliance, but this could not be confirmed by their data and also in our study this is not the case: Table 6.3 shows that based on our data motivation was significantly positively associated to compliance (β_6: 0.382 with $p = 0.001$) but not with participation (β_6: 0.193 with $p = 0.109$).

As based on the obtained data, the partial mediational effect of employees' food safety knowledge (a cognitive loaded variable) and food safety motivation (a motivational loaded variable) could be demonstrated, it can be assumed that it could be beneficial for food companies to keep optimizing and investing in education and training, as food safety knowledge affects both compliance and participation of employees in the organization. The importance of knowledge was also illustrated by Wallace, Holyoak, Powell, and Dykes (2012) in which it is stated that weaknesses in a HACCP team's knowledge about how to apply HACCP principles, can lead to weaknesses in the system. Also Fatimah et al. (2014) and Arendt, Strohbehn, Meyer, and Paez (2011) mentioned the importance of employees' knowledge and self-motivation for performing safe food handling practices. Nyarugwe et al. (2016) considered knowledge as an employee characteristic which should be taken into account when executing food safety culture research. Still, it should be noted that in this chapter, the variable food safety knowledge relates to subjective knowledge, as 'perceived knowledge' is assessed.

Based on our findings, it can also be concluded that organizations should try to keep their employees motivated regarding food issues by e.g. enhancing the food safety climate in the work unit or advocating a behavioral based safety strategy in the organization (Kaila, 2011), as higher food safety motivation is related to a higher food safety compliance. The relationship between lack of motivation amongst employees and management in an organization and a poor food safety culture was also considered by Nayak and Waterson (2016).

Investigation of research question 3 led to the conclusion that, based on our results, the strength of the relationship between food safety climate and food safety behavior was not dependent on different levels of burnout or job stress. Several possible explanations are proposed to explain the absence of moderation. First, it could be possible that interactions were suppressed by statistical overcorrection. As control variable conscientiousness is strongly and significantly correlated (Table 6.1) with all three dependent variables (compliance, participation and behavior: r = 0.71, 0.65 and 0.73), moderation was tested again without incorporating conscientiousness as a control variable. However, still no moderation effect could be proven. Secondly, the burnout values measured in the two investigated companies were rather low, which could be the cause of not being able to prove the moderation effect, as no high burnout values were incorporated in the dataset. This cannot be considered as a cause for the absence of a moderation effect for jobstress, as responses were spread over the whole answering scale (1 → 7). The sample includes respondents with high, medium and low reported jobstress. However, for jobstress, the assessment method could be questioned as only a single item scale was used. Furthermore, it could be that this single item ("How often do you feel stressed because of your job?") was too generic and more specific job related questions should have been asked.

A third possible explanation is the low sample size (n=85), which implies lower test power of food safety climate and its interaction with burnout and jobstress, and higher risk of type-II error. This drawback might be captured by using a larger dataset in further research which could unveil missed relations in the current study. Fourthly, it could be possible that other variables were important and influenced the strength of the relationship between food safety climate and employees' food safety behavior, which were not considered in this study.

However, the fact that our data could not prove a moderation effect of burnout and jobstress does not imply that employees' psychosocial well-being in food companies is not important, as from Table 6.1 can be concluded that jobstress and burnout are both statistically significantly (negatively) correlated to food safety climate and food safety behavior. Moreover, like in other types of industry, psychosocial risk management is of strategic importance also in food industry. Given the dynamic environments in which people work and the adverse effects of work stressors on organizational performance and on employees' well-being, behavior and morale, it is important for management to take steps to reduce psychosocial risk factors in the workplace. 'Psychosocial risk factors' refer to organizational and/or work factors (e.g. workload, time pressure, lack of job autonomy,...) and interpersonal relationships (e.g. abusive supervision, bullying,...) in the work setting that may affect the health of workers.

The human resources department in collaboration with the safety and health department of an organization play a key role in controlling these risk factors, by regularly assessing burnout and jobstress levels in the organization, by identifying and trying to minimize psychosocial risks, and by developing, implementing and evaluating particular stress-management interventions (e.g. enhancing resilience, talent development, job redesigning, employee assistance programs, career management, etc.). Specifically for a food context (food service operations), the research of Pienaar and Willemse (2008) showed that especially stress management techniques such as relaxation, training and visualization or meditation which are focusing on addressing symptoms can be beneficial.

Further scientific research might focus on the interplay between good practices regarding food safety management and human resources management (e.g. management of employees' psychosocial (un)well-being). Also, it should explore whether, when and how a strong food safety climate combined with high psychological well-being among employees can foster food safety performance/output in food organizations. Enhancement of employees' well-being by a good food safety climate should be studied. This should imply that jobstress and burnout are better considered as consequences instead of moderating variables.

The positioning of this research study within the bigger framework of food safety culture, is illustrated in Figure 6.1. In this study the authors focused on the human route on an individual level, which is part of the bigger framework, being the food safety culture. The mechanism by which food safety climate could result in a certain food safety behavior was investigated. This mechanism can be considered as a part of the total food safety culture model, as this food safety behavior could influence the eventual output by e.g. taking right/wrong decisions and following/disregarding procedures (e.g. Holman et al. (2014)). However, both the human route and the technology and management based route (e.g. effectiveness of the FSMS) will be determining the eventual output and all these aspects are incorporated in the bigger framework of the organization's food safety culture.

The presented results need to be interpreted with caution, owing to some study limitations. Firstly, a major part of the proposed model was developed based on safety behavior research in a non-food context. However, several authors (Jespersen, 2015; Taylor, 2011; Yiannas, 2015) already demonstrated that general psychological and behavioral frameworks can also be applied to a food safety context. Also, exclusively self-report measures were used in this study. These measures can cause common method variance and self-report bias (Podsakoff, S.B., Lee, & Podsakoff, 2003). Individuals tend to give the answer that is socially desirable and will overreport desirable behaviors and underreport the undesirable ones (Donaldson & Grant-Vallone, 2002). However, as self-report bias is depending on many factors (e.g. nature of the question, personal characteristics, propensity to give socially desirable response, fear for punishment or situational pressures), it cannot be completely eliminated (Donaldson & Grant-Vallone, 2002). Nevertheless, by guaranteeing anonymity (closed stamped envelope, addressed to the researchers directly) and using existing valid scales, the authors tried to limit this bias.

The small sample size (n=85) could also be a drawback, resulting in a potential decrease of predictive power and missed relations between variables. However, as the authors wanted to rule out differences in national culture in the model (Nyarugwe et al., 2016) and Belgian vegetable processing companies in a similar company context (e.g. family-based SME) are limited in number, it was not really possible to increase the sample size.

A potential bias could also be caused by the higher response rate (30%) of supervisors/leaders in company 2, as this does not represent the real situation in proportion of supervisors versus operators in the company. Harris and Schaubroeck (1988) reported that correlations between the self-rating and peer or supervisor-rating are lower for managers/professionals than for blue-collars/operators. This suggests that supervisors/leaders' responses are less accurate, which means that results for company 2 could be more biased. However, in the case study performed in chapter 2 no significant difference could be found between the food safety climate scores of the operators and their managers.

Next, as our findings are based on a cross-sectional research design, no causal statements can be inferred. Although the present study has shown that there is a strong positive relationship between food safety climate and food safety behavior and that this relationship is partly mediated by employees' food safety motivation and knowledge, further longitudinal studies are needed to investigate potential causal effects.

Finally, even though the present study was embedded within the bigger framework of food safety culture and focused solely on the human route at an individual level, further research is needed to study the synergetic effect of the human route and the technological/managerial based route and/or the joined effect of the human route at both individual and organizational level on food safety outcomes.

6.8 Conclusion

Based on regression analysis of the obtained data through a self-assessment survey from two vegetable processing companies (with 85 employees responding), it can be concluded that based on our obtained data (1) food safety climate was both directly and indirectly related to employees' food safety compliance, participation and behavior; (2) food safety knowledge was a partial mediator in the relationship between food safety climate and food safety behavior; (3) food safety motivation was also a partial mediator but only in the relation between food safety climate and participation and behavior, as motivation appeared to have had no mediating role between food safety climate and participation; and (4) the strength of the relation between food safety climate and food safety behavior was statistically not significantly associated with employees' well-being as the moderating role of both burnout and jobstress could not be proven.

These results demonstrate the importance of human factors in the context of food safety and suggest that an expansion of the conceptual food safety culture model (section 1.4.2), by introducing food safety behavior, knowledge, motivation, burnout and jobstress of the individual employees in the organization is a promising avenue towards a more human behavioral approach to food safety management. This expanded model offers a more nuanced comprehensive view on food safety culture in food companies.

However, it should also be noted that human behavior is a complex 'process' and fully predicting or modelling this behavior is unlikely, as numerous positive and negative demands and resources are at stake and organizations are continuously changing. Besides these limitations, this research clearly demonstrates the importance of the individual level in organizational food safety and gave interesting insights in the relationship between food safety climate and food safety behavior.

Chapter 7:

General Discussion and Conclusion

7.1 Research objectives revisited

Research objective 1: development and validation of a tool to measure food safety climate in food companies

Based on literature study, elaboration of definitions and the conceptual model discussed in chapter 1, in chapter 2 a food safety culture self-assessment tool with 28 indicators and Likert based answer scale was developed and validated through expert validation. Furthermore a pilot study was performed in chapter 2 in affiliated butcher shops with a central management and FSMS. The self-assessment of the food safety climate led to interesting and challenging insights in the human dimension of their organization, as for example some differences in perceptions between managers and operators could be unraveled. This tool was then used in all subsequent chapters (3, 4, 5 and 6) to assess the food safety climate in food companies.

However, the question could be raised whether our food safety climate self-assessment tool, is the one and only tool to be used by food companies or researchers when investigating food safety climate? The elaboration of the definitional framework and development of the tool, as described in chapters 1 and 2, took place in an early phase of the research, being also an early phase of the general development and public integration of the concept food safety culture as such. Ever since, several culture assessment methods have been developed and used (e.g. Jespersen et al. (2016); Wright et al. (2012)). Jespersen, Griffiths, et al. (2017) investigated existing culture evaluation systems and focused on eight systems, five scientifically-based (including our food safety climate self-assessment tool as described in chapter 2 and used throughout this doctoral dissertation) and three commercial systems, which are most often used in food industry. Each of these tools or 'models' have their own application, use certain methods and identify a number of dimensions or components. An overview of the eight tools, as described by Jespersen, Griffiths, et al. (2017) is given in Table 7.1.

It should be noted that not all of these tools or 'models' (Table 7.1) as described by Jespersen, Griffiths, et al. (2017), could be consulted or discussed in previous chapters of this doctoral dissertation, as at the time our framework and tool were developed, many of these tools were not available or accessible in scientific literature. Also, the 'CEB model', the 'NSF model' and the 'Denison model' do not focus on food safety. Another remark about Table 7.1 is the fact that the authors mention that in our 'De Boeck model' only self-assment surveys are used to assess food safety culture (which are actually assessing food safety 'climate') (see Table 7.1). However, chapters 3 and 5 demonstrate how our food safety climate self-assessment survey can be used in parallel with other

Table 7.1: Overview of most often used culture assessment methods in food industry as described by Jespersen, Griffiths, et al. (2017)

Tool or model	Application	Method	Dimensions/components
'De Boeck model' Ghent University As described in chapter 2	-Assess food safety culture -Only pilot study in butcher shops (chapter 2) is mentioned	-Self-assessment survey	-Leadership -Communication -Commitment -Resources -Risk awareness
'Ball model' University of Guelph (Ball, Wilcock, & Aung, 2009; Wilcock, Ball, & Fajumo, 2011)	-Assess food safety culture -Applied in five Canadian food processing companies	-Self-assessment survey -In-depth interviews -Observations -Second self-assessment survey	-Management commitment -Supervisor commitment -Training -Infrastructure support -Worker commitment -Worker behaviors
'Denison model' University of Michigan (Denison, 1997; Denison & Mishra, 1995)	-Assess organizational culture, not specific for food safety culture -Applied in global organizations	-Self-assessment survey	-Mission -Involvement -Consistency -Adaptability
'Jespersen model' University of Guelph (Jespersen et al., 2016; Jespersen & Huffman, 2014)	-Assess food safety culture and food safety maturity -Applied in a North American global food manufacturing company	-Self-assessment survey -Behavioral observations -Behavioral interviews -Performance assessments	-Perceived value -People systems -Process thinking -Technology enabler -Tools and infrastructure
'Wright model' On commission of the UK Food Standards Agency (FSA) (Wright et al., 2012)	-Assess food safety culture -To be used by FSA public health inspectors	-Staff interviews -Management reviews -Incident reviews	-Perception of safety -Business Priority -Leadership -Ownership of safety -Competence -Employee communication -Employee involvement -Risk perception
'TSI model' Developed by Taylor Shannon International (TSI, 2015)	-Assess food safety culture -Used as a commercial audit tool in food service operations in Dubai and small food processing companies in UK	-Self-assessment survey	-Purpose -People -Process -Proactivity
'NSF model' Developed by NSF Consultancy (in collaboration with Cognisco Ltd. Cranfield, Bedford, UK) (NSF, 2017)	-Assess culture maturity -Used commercially	-Review of policies and procedures Operational observations -Sampling -Structured interviews -Psychological assessments	-Culture and awareness -Management -Training -Regulatory compliance -Policies and standard -Auditing -Traceability -IT systems
'CEB model' (CEB, 2017)	-Assess quality of culture -Used commercially	-Self-assessment survey	-Leadership emphasis -Message credibility -Peer involvement -Employee ownership

methods (triangulation) such as verification of monitoring data and internal audits, to gain insight in several aspects of an organization’s food safety culture.

Jespersen, Griffiths, et al. (2017) also investigated validation strategies, with validation defined as the method’s accuracy (Trochim, 2006). Validation of commercial systems (TSI, CEB and NSF) appeared to be less transparent, compared to validation strategies applied in the scientifically-based evaluation models (Ball, Jespersen, De Boeck, Wright, Denison models), as detailed information was missing for these commercial models. The authors concluded that many models applied internal, face and construct validation. Indeed, also our tool went through different types of validation throughout the different chapters of this doctoral dissertation.

‘Internal validity’ of our tool can be assumed, as our tool was developed in close collaboration with the food industry for the subject under investigation (food hygiene and food safety) and as the tool was adapted to the company’s terminology and practical operation based on discussion with internals from the company before each use.

‘Face validity’ was used in the development stage of our tool, as researchers and an expert panel assessed whether the method (self-assessment) and the 28 indicators seemed like a good translation or operationalization of the ‘food safety climate’ construct. As such, the validation results described in chapter 2 can be considered as empirical evidence for the face validity of our tool.

‘Construct validity’ of our tool was shown as well as the construct measured through our tool (food safety climate) correlated significantly, as expected, with other constructs such as employees’ food safety behavior (see chapter 6), suggesting that our tool measures what it is supposed to measure.

Another type of validation, ‘discriminant validity’, was applied in chapter 3, as the tool was able to discriminate between the food safety climate in affiliated butcher shops and the food safety climate in farm butcheries.

Also ‘criterion validity’ was analyzed in this doctoral dissertation, as it was considered whether results of the food safety climate assessment tool can be linked to a certain outcome, being internal audit results (chapter 5), percentage of non-conformance of CCPs (chapter 5) or level of microbiological food safety and hygiene (Chapter 3).

In chapter 5, ‘factorial validity’ of the tool was investigated by exploratory factor analysis. Although factors extracted during analysis did not completely match with our five dimensions, results revealed some interesting insights related to the importance of leadership for food safety climate for the sample of (quality) managers under investigation. These results could be sample dependent, as no frontline employees were included in the sample of respondents. Moreover, exploratory factor analysis is considered a 'large sample procedure' and, for example, Costello and Osborne (2005) propose a 20 : 1 respondent to item ratio. Therefore, the factor structure of our food safety climate self-assessment tool should be unraveled in further research.

'Predictive validity' was not tested during this doctoral research, whilst the Ball model and Denison model did include this type of validation (Jespersen, Griffiths, et al., 2017). Predictive validation would demonstrate that our tool would be able to predict certain outcomes, e.g. complaints. This type of validation could be executed by assessing the number of complaints before and after a certain food safety climate intervention (e.g. education and training about principles of food safety climate).

Besides validation, Jespersen, Griffiths, et al. (2017) stress the importance of reliability testing as this reflects the method's ability to produce consistent or repeatable results (Trochim, 2006). This could be executed by a 'test-retest' method, to assess stability over time. However, retesting with the same questionnaire or tool can induce a certain bias, as responses in the retest could be dependent on memory of responses given during the first test (Lievens, Reeve, & Heggestad, 2007). Reliability of our tool was shown through Cronbach's alfa, revealing high internal consistency of the total scale and each of the five proposed food safety climate subscales as well (see chapter 6).

Jespersen, Griffiths, et al. (2017) also performed content analysis of the eight tools and identified five food safety culture dimensions, which were covered to varying degrees by the eight tools under evaluation (see dimensions Table 7.1). The five identified dimensions by Jespersen, Griffiths, et al. (2017) are Values and mission, including statements related to e.g. compliance, goals and strategy; People Systems, with statements related to group roles, education and training; Consistency, consisting of statements dealing with e.g. decisions and use of technology; Adaptability, which is dealing with e.g. continuous improvement and change readiness (how the organization copes with external contingencies and changes); and Risk awareness, dealing with leaders' and operators' perceptions of risks. According to the authors, the 28 indicators of our food safety climate self-assessment tool cover aspects of all identified dimensions except 'adaptability'. However, although adaptability was not included as a separate component in our tool, indicator L6: 'in my organization, the leaders strive for a continuous improvement of hygiene and food safety', is clearly dealing with continuous improvement, which is within the scope of dimension 'adaptability' as defined by Jespersen, Griffiths, et al. (2017).

Many authors (Griffith et al., 2010a; Powell et al., 2011; Yiannas, 2009) proposed components of food safety culture. Although not all of them use the same terminology, components cited by most authors are in line with the insights and ideas reflected by the components proposed in our research. Recently Nyarugwe et al. (2016) performed an analysis of the existing food safety culture literature and concluded that “food safety culture should acknowledge the impact of national culture, specify hierarchical level(s), establish underlying mechanisms, and consider the company’s food risks and context characteristics” (p. 77). The authors also stated that major elements to be considered in food safety culture research are the following: “organizational and administrative characteristics (i.e. food safety vision, communication, commitment, leadership, training), technical facilities/resources (i.e. food hygiene/safety tools, equipment and facilities), employee characteristics (i.e. attitudes, knowledge, perceptions and risk awareness), group characteristics, crucial FSMS characteristics, and actual food safety performance” (p. 77). The elements mentioned by Nyarugwe et al. (2016) were also incorporated (sometimes implicitly) in our food safety culture model, supporting the ‘content validity’ of our definitional framework. Nevertheless, many of these principles are not ‘new’ and were already included in, for example, certification requirements. Still, if we are talking of a real mature ‘food safety culture’, we do not mean ‘just checking off boxes with requirements’ to obtain certification, but these principles should be ingrained in the company culture and understood and supported by all employees.

An important remark to make concerning the definitional framework is that to our knowledge no other studies in the specific field of food safety culture use both concepts, food safety climate and food safety culture, in their tools or framework. This is striking, since these terms have been thoroughly described in different fields such as safety climate/culture research in non-food contexts which is illustrated in section 1.3.4 (Wiegmann et al., 2002). Another remark concerning the definitional framework, could be the fact that our definition of food safety culture is rather different from other definitions proposed in (food) safety culture and climate research. As, for example, Griffith et al. (2010b) defines food safety culture as “the aggregation of the prevailing, relatively constant, learned, shared attitudes, values and beliefs contributing to the hygiene behaviors used within a particular food handling environment” (Griffith et al., 2010b). In this research a more analytical and tangible approach was chosen, starting from a conceptual model, which has shifted towards an analytical model, as different aspects of the food safety culture model were measured throughout the chapters. However, by introducing our definition of food safety culture, we do not reject the food safety culture definition of Griffith. As by assessing the different elements in our conceptual model, and combining measurement results, information can be gained about these “prevailing, relatively constant, learned, shared attitudes, values and beliefs contributing to the hygiene behaviors used within a particular food handling environment”. Furthermore, other elements may be relevant in food safety culture research and could be added to our model. For example, national culture differences and the existence of subcultures within an organization have been proven to be relevant in food safety culture research (Manning, 2017; Nyarugwe et al., 2016).

In conclusion, the objective of developing and validating a food safety climate assessment tool is reached in this doctoral dissertation. However, did we develop the one and only tool? No, but this is not to be expected. In the end, it will be about the key principles (e.g. effective leadership and communication) of food safety culture. As illustrated in the study of Jespersen et al. (2017) similar principles come back in each of the evaluation tools. 'How' companies will measure their food safety culture and which tool they exactly will use, can be more fit-for-purpose and varying according to the company-own situation and the intended assessment goals.

Still, with the current knowledge, gained since the development of the food safety climate self-assessment tool in the early days of this doctoral dissertation, there could be doubts about the appropriateness of certain indicators. In chapter 5 two indicators appeared to give more missing values than all others (little MCAR test: p = 0.036). For indicator M6 'In my organization, good procedures and instructions concerning hygiene and food safety are in place', and indicator E3 'working in a hygienic and food safe way is recognized and rewarded' , in total, 7 and 4 missing values were reported respectively. As discussed in chapter 5, the terms 'procedures' and 'instructions', could pose difficulties for non-managerial staff, as they might not understand the link with their day-to-day tasks, e.g. procedure for cleaning and disinfection. This demonstrates the need to adapt the statements of the tool to the company-own situation and to the type of respondents, as this statement (M6) could be removed in case of surveying frontline staff. For indicator E3, as already discussed in chapter 5, 'rewarded' might be too strong as this can be interpreted by respondents as 'physical/financial' rewards. Potential evidence for this finding can be seen in chapter 4, as a large number of respondents (39.7%) did not agree, nor disagree with statement E3, whilst responses for other indicators were mostly 4 'Agree'. Still, in many organizations it is rather common that the organization's staff receives a bonus or financial reward if Key Performance Indicators (KPI's) are reached (Parmenter, 2015). Once more, this demonstrates that it could be beneficial to discuss or pilot test the exact phrasing of the statements/indicators (e.g. 'rewarded', 'recognized') with the organization's management and employees beforehand, and adapt the tool to the situation, assessment goals and type of respondents/organization.

Research objective 2: Study food safety climate and culture at an organizational level

Chapters 2 (pilot study), 3, 4 and 5 all study food safety climate or/and food safety culture at an organizational level, meaning that the organization is the entity under investigation. This means we did not focus on the individual employee with his/her individual characteristics, attitudes and behavior, but we used the food safety climate self-assessment tool (combined with other assessment methods in chapter 3 and 5), to map the food safety climate and culture of the organization as a whole.

Chapter 3 and 4 both investigate the impact of organizational characteristics. In chapter 3 this was done in a case study comparing the food safety culture, as proposed in our conceptual food safety culture model, of micro scale farm butcheries, exemplifying a short food chain, and affiliated butcher shops, affiliates of one large scale centrally coordinated meat distribution company, representing the conventional food chain, whilst in chapter 4 a more quantitative nation-wide study was performed.

In chapter 3, the food safety climate was perceived significantly better by employees of the affiliated butcher shops than by the employees of the farm butcheries. Furthermore, affiliated butcher shops are able to counter their risky context (high level of risk towards microbiological contamination) by a well elaborated and fit-for-purpose FSMS, whilst the farm butcheries have a more basic/generic FSMS which is not tailored to the company-own situation (lower level) and have no information available about their system output (no follow-up of product sampling, complaints, audits, etc.), which was assessed by means of the diagnostic instrument. Also the microbiological hygiene and safety status of the farm butcheries was on a lower level (based on microbiological sampling), suggesting that the farm butcheries needed to improve their basic prerequisites such as cleaning and disinfection. Assessing all these aspects in the different butcheries, gives information about the food safety culture of the company (see Figure 1.3), so actually ‘triangulation’, although not the main goal of the chapter, was already performed in chapter 3, before the term ‘triangulation’ as such, really got introduced in the food safety culture research domain, as Jespersen and Wallace (2017) were the first to use this term in this research field. Similar to the triangulation results of some of the food service operations in chapter 5, some farm butcheries, although perceived lower than the affiliated butcher shops, perceive their food safety climate to be on a good level (mode of 4), whereas their FSMS, system output and microbiological hygiene and food safety of products appeared to be on a lower level. So at these restaurants/cafeterias and farm butcheries, employees seem to be unaware of the potential food hygiene/food safety issues at their workplace and seem to overestimate their food safety climate. This optimistic bias can pose a dangerous situation (Rossi et al., 2017). Griffith (2000) actually uses the term ‘complacency’, defined as “self-satisfaction especially when accompanied by unawareness of actual dangers or deficiencies” (Signore, 2010) and considers it as one of the greatest hazards which may occur after a successful implementation of HACCP. Complacency has already been identified as a ‘hazard’ in several non-food sectors, in which ‘hazard’ is defined as “an unsafe condition or activity that, if left uncontrolled, can contribute to an incident” (Mitropoulos, Abdelhamid, & Howell, 2005). For example, Eiter, Kosmoski, and Connor (2016) identified complacency as a reason for arc flash incidents at mine sites and Braithwaite, Caves, and Faulkner (1998) studied the effect of complacency in aviation safety. In the latter study, again effective communication is stressed, which is, according to the authors, one of the most important measures to mitigate complacency and potential consequences. What this ‘effective communication’ implies in practice could be further investigated in interdisciplinary research between experts in communication sciences and experts in food safety management. Also with respect to patient safety, optimistic bias resulting from complacency, was identified as one of the major causes of surgical errors in the study of Skevington, Langdon, and Giddins (2012).

Interestingly components/indicators responsible for differences in perceptions of food safety climate between farm butcheries and affiliated butcher shops were mainly communication and leadership related, as these were perceived to be on a higher level in affiliated butcher shops. This indicates that the negative consequences of the larger organizational size and delocalization of the different affiliates are adequately managed by the central management by for instance regular communication and/or effective leadership, which is expressed in the fact that employees perceive food safety climate to be better. This was also seen in chapter 4 where companies with multiple sites in Belgium perceive the food safety climate to be better than one-site companies, which was again expressed in a significant difference in components leadership and communication (and also commitment). Indeed, it appears that having multiple sites spread over the whole nation requires more structured communication in which the food safety policy is more clear and better leadership skills are present. Furthermore, in these larger firms (with multiple sites) more trained and specialized people are available to manage communication and leadership in an effective way (Daft, 2009; Griffith et al., 2010b). However, for companies with sites spread outside Belgium, this more structured communication and clear food safety policy managed by skilled people might nog be sufficient to overcome e.g. language – and/or national culture barriers, as for international multiple-site companies no higher food safety climate scores could be found (Nyarugwe et al., 2016). These language and national culture barriers within food safety culture were out of scope of the current doctoral research, but could be an interesting area for further research.

An important way to communicate and spread the food safety message is by training (Yiannas, 2009). Indeed, in chapter 4, frequency of training appeared to be a determining organizational characteristic as highly significant differences in food safety climate scores were noticed. Food companies providing more than one food safety training session per year, perceived their food safety climate to be on a higher level than food companies providing less training. Training participation of employees can be fostered by giving up ‘valuable production time’, motivating employees to follow food safety training and managerial behavior which prioritizes food safety over productivity.

However, for training to be effective also type of training and training quality are of importance (Hoehl et al., 2009). Egan et al. (2007) discuss several training methods used in food manufacturing, retail and catering, such as, lecture format, computer interactive training sessions, webinars, etc. Burke et al. (2006) found that training methods requiring active participation of trainees, resulted in greater knowledge acquisition and more behavioral improvements. Although many organizations acknowledge the importance of training, there is only little attention to whether the training was effective or not (Zaciewski, 2001). Zaciewski (2001) stresses the importance of assessing training effectiveness. Also ISO 9001:2015 (ISO, 2015b) states in requirement 7.2.c that the organization shall "evaluate the effectiveness of the actions taken", which is referring to, for example, training activities to ensure employees' competences. Food companies should reflect on which type of training would be most appropriate for the company's specific situation and also on how to assess whether the training was effective or not. As this could be difficult for smaller independent companies, sector organizations should assume an important and pro-active role in this. Egan et al. (2007) also investigate methods used to assess training effectiveness. The most convenient method appeared to be the use of pre and post training test scores. However, the authors argue that knowledge change might not immediately transfer into behavioral change. Another assessment method the authors propose is the use of observations. Nevertheless, it will be up to the company to decide, taking into account all practical considerations (e.g. time and cost), which training method and training effectiveness assessment method will be most appropriate.

As already stated above, food safety climate results of chapter 3 and chapter 4 revealed the importance of effective leadership. Moreover, the exploratory factor analysis executed in chapter 4 extracted a leadership-related factor which covered most variance in the data set. But what is effective leadership? As discussed in chapter 4, managers and leaders are not the same (Maccoby, 2000). Griffith et al. (2010a) state that good leaders are able to influence people and that they have a clear food safety vision with goals and standards. This viewpoint is reflected in the definition of component leadership used in the current doctoral research: "(the perception of) the extent to which the organization's leader(s) are able to engage staff in hygiene/safety performance and compliance to meet the organization's goals/vision/standards concerning hygiene and food safety". According to Schein (2017) good leaders have the skill and ability to embed and transmit culture. Leaders will be founders in the creation and development of the organization's culture and will impose their own beliefs, values, assumptions on their subordinates, which then will become the beliefs and values of the organizational culture. The skill leaders dispose of which allows them to do this is, according to Schein (2017),'charisma', the "mysterious ability to capture the subordinates' attention and to communicate major assumptions and values in a vivid and clear manner" (Schein, 2017, p182).

Still, Schein's view on the role of leaders seems rather dictatorial, as ''imposing own values and beliefs on subordinates" is a rather strong statement. Griffith et al. (2010a) states that an indicator for a good food safety culture is that employees consider their own beliefs and values aligned with those of the organization. But also Schein nuances his view, by stating that beliefs, values and assumptions should be in alignment with the macro cultures in which the organization must function. As already mentioned in chapter 1, many types of cultures exist and every culture is part of some larger culture which it has to 'fit in'. This macro culture can be, for example, religious or national in nature (Schein, 2017). Indeed, the importance of national culture has been already pointed out by several authors. For example, Ghemawat and Reiche (2011), state that national culture differences can involve differences in e.g. risk and safety perceptions, values and attitudes, leadership style, which could result in the need for different (research) approaches depending on the national culture. Moreover, because of globalization, companies are confronted with different national cultures. An understanding of these cultures is required to be able to approach individuals in an appropriate and effective way (Nyarugwe et al., 2016). As an example Hofstede et al. (2010) describe differences in 'power distance' among different national cultures. The authors define power distance as "the extent to which the less powerful members of institutions and organizations within a country expect and accept that power is distributed unequally" (p.61). In 'large-power-distance cultures', superiors and subordinates expect inequality and subordinates expect to be told what to do. In 'small-power-distance cultures', subordinates and superiors consider each other as equal, believing that roles (superior versus subordinate) may be changed easily. Superiors are accessible to subordinates and the latter expect to be consulted about decisions affecting their work. A study comparing power distances of the same multinational company in different countries, revealed that in France larger power distances exist, whilst these appeared to be rather small in the Netherlands (Hofstede et al., 2010). Clearly, these differences will require different approaches to be taken by food business operators, in for instance the perceived and preferred leadership style of 'the boss'.

Another practical implication concerning the importance of leadership is, that in the selection procedure of, for example, a quality manager in a food company, the human resources department involved in the selection procedure, should not only look at required technical skills, but should also include leadership skills. Further research could investigate how to assess 'leadership skills' and which leadership styles are most appropriate for a quality manager in a food (processing) company. For example, authentic leadership, which is a fair and supportive type of leadership, is considered to be relevant in a nursing context (Mortier et al., 2016) and to foster the safety climate in the international shipping industry (Borgersen, Larsson, & Eid, 2014). Griffith et al. (2010a) discuss many types of leadership in a food safety context. For example, transformational leaders motivate employees to adopt the organization's goals and to set aside personal goals, whilst transactional leaders motivate employees by clarifying their role in the organization, meeting their needs and providing appropriate rewards (Griffith et al., 2010a). The authors also state that good leaders might have to employ more than one leadership style and might have to change their style at different times and with different people.

An important bias in chapter 4, is the fact that conclusions are solely based on the food safety climate self-assessment tool, and thus on perceptions. Therefore triangulation of three methods was performed in chapter 5, which allows to gain information about different aspects of food safety culture and to counterbalance weaknesses in each of the used methods. In 16 locations of the UGent university food service operation, internal audits and verification of monitoring data, primarily belonging to the techno-managerial route (Figure 1.3), although internal audits may already include human factors, were linked with results of the food safety climate self-assessment tool, shedding light on the human route within food safety culture (Figure 1.3). By a case-by-case investigation of the results of the three methods, a more comprehensive evaluation of food safety culture is possible.

A remark which could be made is the fact that in chapter 5 (and chapter 3), 'triangulation' is approached in a different way than in in the research of Jespersen and Wallace (2017). In the latter research, food safety culture is measured by assessing five dimensions through three methods: documentation, self-assessment surveys and interviews, whilst in chapter 5 (and chapter 3), insights in food safety culture and the underlying values, beliefs and asssumptions, food safety culture is about, are gained through combining assessments of elements of food safety culture, as defined in our food safety culture conceptual model (Figure 1.3). However, from both perspectives the same message can be deduced, being not to rely on a single method, but to use different approaches in order to overcome weaknesses of each single method, in order to get to these underlying values, beliefs and assumptions. Still, the question can be raised whether the full picture of food safety culture can be assessed through the use of our conceptual model; by combining measurements of the proposed food safety culture aspects in this model. Indeed, as stated in section 7.1 (vide supra) other elements could be introduced (e.g. national culture), but food safety culture is measured in this dissertation based on our model and definition. Still, we acknowledge that also other approaches and other tools exist.

Next to the reflection raised in section 5.5 about the fact that the used methods have no one on one relation with the number of foodborne illnesses, another important remark can be made with respect to the HACCP plan of the food service operation under study in chapter 5. Many CCPs as defined in the HACCP plan, are actually 'general preventive measures' and are therefore belonging, sensu stricto, to the PRPs, which are defined in the recent EU Commission notice as "preventive practices and conditions needed prior to and during the implementation of HACCP and which are essential for food safety" (EU_Commission, 2016). For example, the preventive measure of maintaining cold temperatures in buffets, a process step which has been validated proving that no substantial growth of pathogenic micro-organisms can occur during this period, is wrongly considered a CCP in this case. Furthermore, PRPs are actually dealing with 'food hygiene' (see section 1.1.1: defintion food hygiene), as the link of PRPs with food safety is rather indirect. However, if we 'loosen' food hygiene, in the long term, food safety might be compromised. On the other hand, a CCP, defined as "a step at which control can be applied and is essential to prevent or eliminate a food safety hazard or reduce it to an acceptable level" (EU_Commission, 2016), is more directly affecting 'food safety'. For example, in this case study, CCP5 (regeneration temperatures) can be considered a justifiable CCP. This mix-up between PRPs and CCPs is actually a general problem in some sectors (especially in business-to-consumer (B2C) sectors) as the HACCP plan of the food service operation in our case study is based on the national self-checking guide for the catering and care facilities sector and on B2C 'quick start fiches'(FASFC, 2018), which are both approved by the competent authorities. These B2C quick start fiches, which can also be used in other B2C sectors such as the butcheries in chapter 3, are actually complementary to the self-checking guide, and summarize the most important principles in a more practical and simplified manner. In these B2C quick start fiches and national self-checking guide, certain preventive measures such as storage temperature of food products and reception of raw materials are, sensu stricto, wrongly indicated as CCPs, which was actually a risk management/policy decision, probably because it was deemed inappropriate not to have any CCP in a HACCP plan. However, in case of the butcheries, the recent EFSA opinion 'Hazard analysis approaches for certain small retail establishments in view of the application of their food safety management systems' (EFSA_BIOHAZ, 2017), which is applicable to small retailers such as also ice cream shops and bakeries (see section 1.1.2), rectifies this mix-up between PRPs and CCPs. In the EFSA Opinion, a HACCP approach is presented which is focused on safeguarding PRPs, without the need of CCPs. This illustrates that we have to pay attention that, although in some cases some flexibility and simplification in the implementation of food safety management systems is necessary, we do not lose track of the fundamentals behind it.

In summary, from chapter 3, 4 and 5 about culture and climate at an organizational level we can conclude that effective leadership and communication are important to spread the food safety culture message and to make sure employees know and perceive that food safety is valued in the organization. This can be done, for example, by providing frequent food safety/hygiene related training sessions, as this has an impact on food safety climate perceptions. Important to note with respect to these results, is the fact that through the food safety climate self-assessment tool, ‘perceived’ leadership and ‘perceived’ communication were measured. However, only considering perceptions in food safety culture research could lead to wrong conclusions because of the weaknesses of one single method. By triangulation of different assessment methods (as executed in chapters 3 and 5), different aspects of food safety culture at an organizational level could be investigated. By combining system and product related measurement methods (e.g. internal audits and verification of monitoring data) (belonging to the techno-managerial route) and a people related method (e.g. employee perceptions through a food safety climate tool) (belonging to the human route) case by case, a better understanding of the food safety culture at the different locations could be gained. Also, locations where an optimistic bias and complacency prevails, which might result in a dangerous situation, could be identified.

Research objective 3: Study food safety climate at the level of the individual employee

In the end it all comes down to the individual, whether or not he/she will comply with procedures and which decisions will be made every day, hour and even minute to obtain a high level of food hygiene and/or safety. To use Powell’s words: “any food producer is only as good as its worst front-line staff” (Powell et al., 2013). As such, in chapter 6 the focus is on the individual instead of the organization as a whole. What drives an employee to adopt a certain food safety behavior? What is the mechanism behind this? Based on research in the safety culture and safety climate domain (e.g. Neal and Griffin (2006); Neal et al. (2000)) the human route of the conceptual model from chapter 1 was further unraveled, including individual food safety behavior, knowledge, motivation, burnout and jobstress. Three research questions were defined within this chapter to investigate the expanded food safety culture conceptual model (Figure 6.1) and to explore food safety culture at the level of the individual. In a first research question the positive relationship between food safety climate and food safety behavior was confirmed. This means that if the individual employee perceives food safety climate to be on a higher level, this employee will adopt a better food safety behavior. This positive association is in line with previous research findings (Fatimah et al., 2014; Nyarugwe et al., 2016).

In a second research question this relationship was further unraveled by exploring food safety motivation and food safety knowledge as potential explanatory mechanisms or mediators between food safety climate and food safety behavior. A partial mediation could be proven, which means that both a direct and indirect relation between food safety climate and food safety behavior exists and other factors, besides knowledge and motivation, such as for example group dynamics (Nyarugwe et al., 2016) could be of importance as well. Indeed, the partial mediational effect in our data might reflect, in line with results obtained from chapter 4, the need to keep optimizing and investing in education and training. Providing regular training sessions encouraged and approved by the management may improve both knowledge and motivation, as management support has already been proven to affect safety motivation in the construction industry (Andriessen, 1978).

The conclusion concerning research question 3 was that, based on our results, the strength of the relationship between food safety climate and food safety behavior was not dependent on different levels of burnout or jobstress. However, Table 6.1 did prove that jobstress and burnout are both significantly and negatively correlated to food safety climate and food safety behavior ($p < 0.05$). In non-food industries, the impact of psychosocial wellbeing on human behavior has been widely described. For example, Alexandrova-Karamanova et al. (2016) associated burnout with medical errors and inadequate patient safety, and Probst and Brubaker (2001) state that employees suffering from jobstress report lower safety knowledge and motivation. More recently, Mitchell, Fraser, and Bearon (2007) demonstrated the importance in the prevention of foodborne illness in food service establishments and argue for a broader approach addressing both individual and contextual factors that influence safe food handling behaviors. As such, it would be beneficial for food companies to assess psychosocial well-being among their staff and investigate strategies to minimize psychosocial risks (Pienaar & Willemse, 2008).

Chapter 6, provides a first exploration of this individual level. Of course, more in-depth work and organizational psychological empirical studies could identify particular personal characteristics of employees which can be strongly associated with ‘good’ (e.g. compliance) or ‘bad’ (e.g. non-compliance) food safety behaviors. Actually, Table 6.1 contains a lot of interesting information based on the obtained data. It shows a significant and positive correlation between job seniority and food safety behavior ($r = 0.25$, $p < 0.05$), but looking at the separate components of food safety behavior, as described by Neal and Griffin (2004), only food safety participation seemed to be significantly correlated with job seniority ($r = 0.26$, $p < 0.05$). So higher job seniority does not correlate with better obligatory food safety activities (food safety compliance, $p > 0.05$). A possible explanation is that in some cases job seniority may result in complacency (McCampbell, Jongpipitporn, Umar, & Ungaree, 1999). Amoako and Lavies (2003) investigated complacency in applying (in)correct labels on drug syringes by medical staff and concluded that complacency grows with job experience. And as already discussed in chapters 3 and 5, complacency can pose a real risk for food safety (Rossi et al., 2017). Therefore it is important to keep all staff, also the experienced people, alert and attentive by, for instance, providing frequent training which is visibly supported by the management (Wiggenhorn, 1994). Another interesting personal characteristic to focus on is conscientiousness (Table 6.1), which is, according to MacCann, Duckworth, and Roberts (2009) comprising several aspects: industriousness, perfectionism, tidiness, procrastination, control, cautiousness, task planning and perseverance. Based on the data obtained in chapter 6, conscientiousness appeared to be significantly and positively correlated with food safety behavior, compliance and participation ($p < 0.01$ Table 6.1). Still, it should be noted that not all 13 items of the 'Conscientiousness Scale' of the 'International Personality Item Pool'(IPIP, 2001) were used for the assessment of conscientiousness. Five of the 13 items were selected based on expert discussions.

Practically, these insights could be used in, for instance, the recruitment and selection activities of a Human resources or Personnel Department of a food company. Organizations can communicate and emphasize individual characteristics, which are proven to be more frequently resulting in positive food safety behaviors, in the advertisements for their vacant jobs. They can assess and measure these individual characteristics (e.g. conscientiousness) in job applicants as well. In a similar way, but in a different work context, Doyen, Vlerick, Vermassen, Maertens, and Van Heirzeele (under review) propose assessment of non-technical attributes and human factors during selection procedures for surgeons. The authors stress the importance of interpersonal skills (e.g. communication) and professional attitudes (e.g. attitudes towards risk/risk-taking behavior) which, besides the technical abilities, can contribute to safe job performance. However, we should make sure that we do not tar everyone with the same brush. For example, based on our data, conscientiousness appeared to be associated with a better food safety behavior. Still, it is not because someone is less conscientious, he/she will not be able to do a good job. Moreover, Doyen et al. (under review) provide evidence that some non-technical attributes may develop and change progressively over time by for example training focusing on non-technical aspects/ human aspects. Additionally, in food industry food handlers are most often not working by themselves, but they work in shifts surrounded by colleagues. Certain ('bad' or 'toxic') personal characteristics may change or be counterbalanced by others in a group environment (Arnold & Silvester, 2005; Yiannas, 2015). So the impact of the relationship with colleagues and group dynamics on human behavior, but also the relation with food safety culture, could be an interesting field to explore further. Still, we have to keep in mind that people and human behaviors are complex and fully predicting or modelling this behavior is unlikely. Also, another important remark to keep in mind is the fact that smaller companies often do not have specialized human resources departments and that sometimes the number of candidates for certain job vacancies are rather restricted. In this case, a balance should be made between 'good/stringent selection criteria' and 'being able to fill job vacancies'.

As already pointed out in chapter 6 the proposed conceptual model was based on previous safety climate and culture research conducted in a variety of industrial sectors. Several authors, active in food safety culture research (e.g. Griffith et al. (2010a); Nyarugwe et al. (2016)) use safety climate and culture research aspects in their food safety culture research. However, is it right to assume that all safety climate or culture research know-how/findings can be applied in food safety culture research? For example, a major dissimilarity between these two research domains is the fact that consequences related to a bad safety culture, are more direct and personally affecting the individual employee, as e.g. accidents on the work floor happen immediately and have an effect on the employee him-/herself and/or direct colleagues (Fernandez-Muniz, Montes-Peon, & Vazquez-Ordas, 2012). In a food safety context, consequences (e.g. foodborne illness) are more lagging and will affect people (consumers) with no direct relation or personal involvement to the individual employee (Yiannas, 2009). This might make it more difficult to engage employees and change behavior in a food safety context. As such, the strategy proposed by Yiannas (2009), using personal stories and testimonies to which the individual employee can relate, could be very powerful to overcome this lagging effect and perception of personal distance. Further research about these (dis)similarities between safety culture/climate and food safety culture/climate and the potential impact on research findings or intervention strategies could provide valuable insights in the food safety culture research domain.

Moreover, further research might reveal whether the relevance, role and added value of a good safety climate, human factors and employees' psycho-social well-being is (dis)similar in a service-oriented organization (e.g. restaurant, cafeteria, butchery,...) versus in a more production-oriented work organization (e.g. food processing company) in which there is less or no contact with the end consumer.

Ethical considerations

Especially with respect to chapter 6, some ethical reflections should be made, as in this chapter personal questions about, for example, feelings of burnout were asked. Although measures were taken to guarantee anonymity (e.g. surveys to be sent by post to researchers in a prestamped envelope without involvement of management) and to make sure employees were informed about the goal and use of results and the voluntary nature of the survey, employees could feel (corporate) pressure to participate, which could lead to inaccurate or socially desirable results. Furthermore, although the management would have been contacted in case of alarming or worrisome results, no formal follow-up or counselling was provided for the participants in the study in chapter 6, as these may experience discomfort when answering questions about their personal feelings related to e.g. burnout and jobstress. However, as a reform of the ethical commissions within Ghent University is expected, these issues could be more consistently addressed in further research.

7.2 Evolution and significance of research and practical implementation of food safety culture and climate

Evolution food safety culture and climate research

As discussed in chapter 1, 'safety culture/climate' research in non-food sectors (e.g. occupational health) was already widely described in literature before 'food safety culture/climate' made its appearance (Neal et al., 2000; Zohar, 1980), since it was first introduced in a report of the Nuclear Safety Advisory Group (INSAG, 1988). Two important events in launching food safety culture research were on the one hand the publication of Frank Yiannas' book "Food Safety Culture: Creating a Behavior-Based Food Safety Management System" (Yiannas, 2009), which, although not based on scientific research, launched the term and got people interested. On the other hand, Chris Griffith set scientific milestones with his food safety culture research at Cardiff University resulting in a number of key publications in the field (Griffith et al., 2010a; Griffith et al., 2010b). The current doctoral research within UGent was launched upon an informal conversation at the European meeting of International Association of Food Protection in Cardiff in April 2015 (IAFP, 2015). Here the idea took shape for the development of a collaborative food safety culture framework between different researchers from all over the world. The 'food safety culture science group', later named 'Salus' (Roman goddess of safety and well-being), was created in 2015 as a an international group of academics, active researchers and practitioners which stand for a scientific approach to food safety culture by developing and sharing food safety culture research, and disseminating and translating research into tools, guidance and advice to the food sector (Salus, 2017). At about the same time in 2015, the topic was picked up by the Global Food Safety Initiative (GFSI), which was originally a benchmarking organization setting benchmarking requirements for food safety certification standards but now evolved into an international industry-driven platform for collaboration, knowledge exchange and networking (GFSI, 2017b). A Technical Working Group for food safety culture was created within GFSI, in which practitioners from industry are assembled to discuss food safety culture (GFSI, 2017a). Also within IAFP 'food safety culture' earned its spot, through the development of the PDG (Professional Development Group) Food safety culture at the IAFP meeting in Tampa, Florida in July 2017 (IAFP, 2017). In February 2018, the GFSI Technical Working Group for Food safety culture, with scientific contribution from Salus, is expected to publish a position paper as an input for the GFSI benchmarking document. This benchmarking document will be used as a benchmark for scheme owners in which high level statements related to food safety culture principles will be included. Scheme owners will translate high level statements in quality assurance standard requirements (e.g. BRC, IFS). Some scheme owners, such as BRC, already offer voluntary modules related to food safety culture, which food companies can choose to add in their certification scope (BRC_global_standards, 2018). However, the question remains whether food safety and food technology oriented auditors possess this set of soft skills in order to be able to assess ‘culture’, as ‘culture’ as such is not to be captured in a simple checklist and might require specific training (Nayak & Waterson, 2017). This would be an interesting area to investigate in further research. Another important milestone in food safety culture research and its practical application, is the fact that principles of food safety culture will be included in the revised version of Codex Alimentarius General Principles of Food Hygiene (Codex_Committee_on_Food_Hygiene, 2017).

Significance for food safety management

An important consideration with regard to food safety climate and culture is to which extent this adds value to the current system of food safety management and whether it is worthwhile for food companies to make these extra efforts and investments. As already mentioned in section 1.1.2, many, often smaller, food companies are having already a hard time to comply with (often complex) legislative requirements and additional requirements from e.g. clients or quality assurance standards. Starting with HACCP and PRPs as initial building blocks of a company’s FSMS, over time more and more building blocks, with related requirements, were added, such as, for example, essential managerial practices, food fraud and food defense (Spink & Moyer, 2011; Wallace et al., 2011).

For company managers this becomes very challenging to prioritize all issues, as also non-food and non-technical factors (e.g. burnout, harassment, bullying) are raised, which are all claimed to be of major importance by different parties/stakeholders (Schulz, Greenley, & Brown, 1995; Zapf & Gross, 2010).

We cannot afford to keep building up blocks and keep expanding requirements. We need to simplify. Assessing and trying to improve the organization’s food safety culture should not be seen as something ‘extra’, some additional burden on top of all requirements food companies already need to comply with. Principles of food safety culture can be integrated the company’s own FSMS, without considering it as a separate ‘thing to do’. By investigating an organization’s food safety culture, or specific dimensions/principles of food safety culture which are of interest for the organization, strengths and weak points in the organization can be identified and this allows food companies to make appropriate decisions about actions and resources (Jespersen & Wallace, 2017). For example, as illustrated in chapter 3, investigation of food safety culture revealed that sometimes it is more difficult in farm butcheries to openly discuss food safety problems with colleagues than in affiliated butcher shops. A potential strategy for these farm butcheries could be to foresee informal meetings at fixed times to allow room for discussion. Also differences in perceptions over different hierarchical levels can be identified (e.g. farm butchery 1 (FB1) in chapter 3) which suggests that people are not on the same page and which can lead to problems in cooperation and trust. Also, by triangulation of three methods assessing different aspects of the food safety culture model, as described in chapter 1, the overarching management of the food service operations in chapter 4 could identify the locations with higher risk, as quite some locations appeared not to be aware of the food safety issues in their location. Furthermore, locations with issues concerning correct and adequate monitoring and registration of CCPs could be revealed. An appropriate action/intervention could be to organize trainings for these locations particularly focusing on raising awareness about the importance of correct monitoring and registration, as this allows to proactively detect problems and respond quickly in case of food safety issues.

If integrated in the company's own FSMS, food safety culture should not be an extra burden to bear. In the future, we might not use the term 'food safety culture' as such, but rather assess cultural elements (e.g. leadership) which are enabling or hindering food safety performance in a company. Indeed, one might consider or conceptualize a food safety culture as a component, a subsystem or an expression of the wider organizational culture of a particular food company expressing how an organization behaves towards and manages food safety, next to other resources (e.g. human resources) and organizational goals (e.g. sustainability, economic profit,...) at large. This might imply, scientifically speaking, that food safety can profit from a more multidisciplinary oriented approach in which both the techno-managerial and human routes towards food safety are captured. From a managerial point of view, food safety would become then a shared responsibility among all organizational stakeholders (e.g. management, leaders and frontline employees) instead of being solely the responsibility of the food quality/safety department, implying that also other organizational departments (e.g. Human resources department) might contribute to improving and fostering food safety in the organization.

However, it should be noted that, of course, not all foodborne illnesses are due to non-compliance of food handlers, or malfunctioning of the FSMS. For example, hazards related to consumer practices or to food products coming directly from primary production and consumed without any form of processing (e.g. unprocessed and uncut fresh vegetables) or hazards related to eating habits, such as for example eating of raw oysters, can also induce foodborne illness (Klontz, Timbo, Fein, & Levy, 1995; Lynch et al., 2009). In these cases, the food company's food safety culture might not have a real impact. Still, this was out of scope of this doctoral research, as the current research focused on food safety culture in food companies dealing with (partly) processed food products, in which food handlers have a significant impact. Whether or not food safety culture would be relevant in e.g. primary production, could be an interesting area for further research. Another refreshing approach would be to look at human behavior/practices linked to 'intentional food safety issues', i.e. 'food fraud', as this may be expected to be influenced by the organization's food safety culture as well.

7.3 Overview of suggestions for further research

Throughout the different chapters of this doctoral dissertation, several suggestions for further research were raised. An overview of these potential research opportunities is given below:

-Further psychometrical validation studies are needed to demonstrate to what extent self-ratings are corresponding with other-ratings (e.g. by auditors, inspectors, colleagues) of food safety climate. This would be helpful to gain insights in how to interpret self-report scales which are based on perceptions (chapter 2).

-A limitation in many of the chapters of this doctoral dissertation was 'sample size'. It would be interesting to investigate the food safety culture in a large scale (multinational) company. Still, in these large scale companies, manual handling by employees is often limited, as many processes are automated. Also, from section 1.2 it could be concluded that many food safety issues are linked to (smaller) catering and food service operations (chapter 2, 3, 5 and 6).

-The use of weighing factors for the different indicators of the food safety climate self-assessment tool was not investigated and could be interesting to explore in further research (chapter 4).

-From chapter 4, it could be seen that providing regular training is important, however not only training frequency should be considered. Also quality of training and type of training would be interesting to investigate. An approach would be to investigate which training methods and types are most effective in order to raise food safety awareness of employees working in food industry. Also the most appropriate methods to measure training effectiveness can be investigated (chapter 4 and 7).

-In further research, the factor structure of the food safety climate self-assessment tool should be unraveled. Confirmatory factor analysis could be performed to see whether other factor structures are possible. Measurement invariance should explore whether the same factor structure can be identified for managers and operators. Moreover, by multisample analysis generalizability of the factor structure can be investigated. These analyses should be performed with a larger sample size (chapter 4 and chapter 7).

-Further research could study the relation or interplay between the human route and the techno-managerial route at both an organizational and an individual level to explore which mechanisms are theoretically behind this double arrow in Figure 1.3. For example, which enabling and constraining factors could be behind this. Also potential synergetic effects between the human route and the techno-managerial based route could be investigated (chapter 4 and chapter7).

-Language and national culture barriers within food safety culture were out of scope of the current doctoral research, but could be an interesting area for further research. With the ongoing internationalization of food legislation/regulation, the globalization of food industry and the societal importance of food safety, a deeper understanding of (dis)similarities in continental and national cultures allows to approach individuals and food industry in an appropriate and effective way (chapter 7).

-The importance of leadership was demonstrated in several chapters of this doctoral dissertation. Further research is needed to identify key leadership skills at low, middle and top management levels of food companies; to explore how these skills can be measured in organizational selection contexts and how these can be learnt through leadership training and development activities (chapter 7).

-As explained above in this chapter, effective communication is an important strategy to prevent and mitigate complacency and to raise awareness regarding food safety and hygiene. Interdisciplinary research between communication sciences and FSMS experts could reveal which communication methods/techniques would be most appropriate to raise awareness and make sure the food safety message is transferred effectively (chapter 7).

-Models and concepts used in this doctoral dissertation were largely based on non-food safety climate or culture research. Further research on (dis)similarities between safety culture/climate and food safety culture/climate and the potential impact on research findings or intervention strategies should be investigated. This type of research might reveal the extent of generalizability of outcomes or effects of safety culture and climate across industrial sectors (chapter 7).

-The impact of interpersonal relations and processes among colleagues (e.g. social support) and group dynamics (e.g. teamwork) at work on employees' food safety behavior and on shaping an organization's food safety culture was out of this doctoral dissertation's research scope and seems to be a promising avenue for further research (chapter 7). Also the existence of subcultures within the overarching food safety culture could be of interest, as Manning (2017) provides evidence for the relevance of four proposed subcultures: executive, operations, engineering and quality with respect to the food safety management in food companies (chapter 6).

-Even though in this doctoral dissertation we demonstrate and illustrate the importance of the food safety climate and food safety culture at large, the question remains whether food safety and food technology oriented auditors are capable to assess 'culture'. 'Culture' as such is not to be captured in a simple checklist and might require specific soft skills, specific training and other types of assessment methods (chapter 7).

-This doctoral dissertation focused on food safety culture in food companies dealing with (partly) processed food, in which food handlers have a significant impact. The question could be raised whether food safety culture would be relevant in e.g. primary production. Do the same principles and food safety climate indicators hold in this context (chapter 7)?

-In the current doctoral dissertation, 'intentional food safety issues' were considered out of scope. Still, human behavior/practices linked to 'intentional food safety issues', i.e. 'food fraud', may be expected to be influenced by the organization's food safety culture as well, which is a theme of high societal importance nowadays (chapter 7).

7.4 Conclusion

To attain the main objective of this doctoral dissertation 'exploring the human factor in food safety management by studying the impact of an organization's food safety culture and climate', a conceptual model was proposed and definitions for food safety climate and culture were set. Furthermore, following a 'Measure what you treasure' approach, a self-assessment tool was developed allowing to measure the food safety climate in food companies. This food safety climate self-assessment tool was at a central position in this doctoral dissertation, as this tool was used throughout all chapters (3, 4, 5 and 6) to gain insight in this human factor of food safety management. Figure 7.1 gives an overview of the main findings throughout this doctoral dissertation and the practical implications for food companies, which could be deduced over all chapters. In other words, where could a food company focus on to improve its food safety culture.

At a central position in this doctoral dissertation (and in Figure 7.1) the food safety climate self-assessment tool can be considered, which was developed in chapter 2 and is consisting of five components: leadership, communication, commitment, resources and risk awareness. Use of this tool in chapter 3 and chapter 4 led to important insights about the first two components: leadership and communication. Practically, the first thing companies could do is reflect on the 'leadership' in the organization, as this appeared to be one of the most important dimensions of food safety climate. Which job positions in the company require appropriate leadership skills and to what extent do these leaders master those skills in the organization? Another important dimension to consider is 'communication'. Interesting questions to ask regarding effective food safety communication are the following: is the food safety message clear in the company? Is food safety included as a priority in the policy of the company? For example, is 'food hygiene/ food safety' included in the organization's

KPI's? Does this message reach the frontline staff? Through the food safety climate self-assessment tool, perceptions of all employees about these two dimensions (leadership and communication), next to perceptions regarding the three other identified food safety climate dimensions (commitment, resources and risk awareness), can be investigated and used to expose strengths and/or weaknesses in these food safety culture aspects.

Secondly, next to measuring employees' perceptions by the self-assessment tool, which is a 'human based' assessment method, also 'techno-managerial' assessment methods should be applied as illustrated in chapter 3 and chapter 5. By triangulation of methods, combining both techno-managerial (e.g. verification of monitoring data) and human route (food safety climate self-assessment tool) oriented methods, different aspects of the food safety culture in an organization can be investigated (Figure 1.3). This allows a more comprehensive evaluation of an organization's food safety culture and potential hazards such as optimistic bias and complacency among employees can be identified.

Thirdly, in chapter 4 and chapter 6, use of our self-assessment tool and further exploration of the individual level of the human route led to insights in the importance of regular education and training. As this allows food companies to solidify weak points by raising awareness and demonstrating that food safety is valued in the company. As such, this can increase both food safety motivation and food safety knowledge of employees, which can influence their food safety behavior. For training to be effective, the company should reflect on which training method is most appropriate in its specific situation and context. Of course, food business operators should be aware of the fact that this will require certain resources, which might not give immediate and tangible results (e.g. no direct effect on number of complaints), as solidifying and maturing the company's food safety culture is a longterm process.

The last main finding illustrated in Figure 7.1, is the fact that food companies should also consider the role of psychosocial well-being, as an influencing factor for employees' food safety behavior. In chapter 6 evidence was provided for the relation between burnout and jobstress, and food safety behavior. The human resources department in collaboration with the quality and food safety department could regularly assess psychosocial risk factors, such as burnout and jobstress levels, in the organization. Indeed, companies with mature food safety cultures are also attentive for these psychosocial factors, by identifying and trying to minimize psychosocial risks, through for example, specific stress-management interventions (e.g. enhancing resilience, talent development, job redesigning, employee assistance programs, career management, etc.). This is of course more difficult in smaller companies, where no human resources department is present. Still, as in smaller companies organizational structures are expected to be less complex and supervisor-subordinate relations are often more informal, psychosocial risks could be unveiled by informal communication instead of applying formal measurement procedures.

Summarized, in this doctoral dissertation we proposed a food safety culture conceptual model, in which food safety climate plays a pivotal role. Specifically, we developed and validated a tool to capture employees' perceptions of the food safety culture in their organization, and we investigated food safety culture and climate at both an organizational and individual level. We hope this exploration of the human factor in food safety management, might inspire both food industry and food scientists to recognize the importance of these human factors and value the food safety culture in a food company.

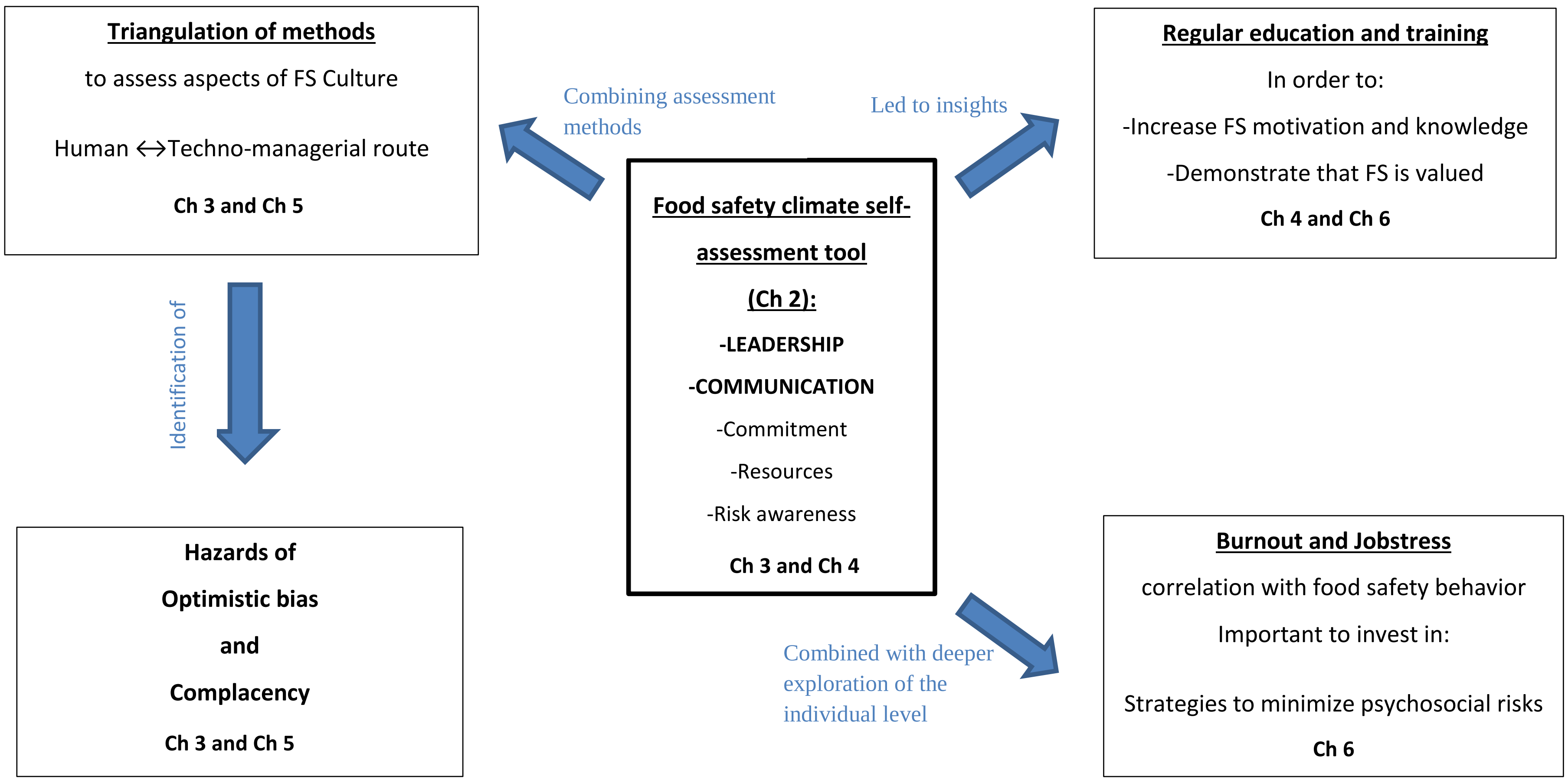

Figure 7.1: Schematic representation of the main findings throughout this doctoral dissertation and practical implications for food companies, which could be deduced over all chapters. FS: Food Safety; Ch: Chapter; ↔: interplay between routes (Figure 1.3)

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Appendices

Appendix 1.A: List of publications dealing with performance measurement of the FSMS in food industry obtained through review of literature in period 2009-June 2017.

Reference	Title	Type of performance measurement: System and product related: Microbiological analyses	Inspections	Internal audits	External audits	Diagnostic instrument	Other	People related: Knowledge	Behavior/ practices	Perception	Culture/ Climate	Country	Company type
Jacxsens et al. (2009)	A Microbiological Assessment Scheme to measure microbial performance of Food Safety Management Systems	X										Belgium and the Netherlands	Meat processing company
Luning and Marcelis (2009)	Systematic assessment of core assurance activities in a company specific food safety management system					X						The Netherlands, Belgium and Spain	Food industry
Griffith et al. (2010a)	The assessment of food safety culture										Food safety culture	NA	Food industry
Jacxsens et al. (2010)	Food safety performance indicators to benchmark food safety output of food safety management systems					X						Belgium, the Netherlands, Spain, Italy and Cyprus	Slaughter houses, Meat processing companies and dairy companies
Park, Kwak, and Chang (2010)	Evaluation of the food safety training for food handlers in restaurant operations							X[b]	X[b,c]			Korea	Restaurants
Psomas et al. (2010)	Critical factors for effective implementation of ISO 9001 in SME service companies					X						Greece	SMEs in food service
Sampers et al. (2010)	Performance of Food Safety Management Systems in poultry meat preparation processing plants in relation to *Campylobacter* spp. contamination	X				X						Belgium and the Netherlands	Meat processing company

Reference	Title	Type of performance measurement: System and product related: Microbiological analyses	Inspections	Internal audits	External audits	Diagnostic instrument	Other	People related: Knowledge	Behavior/ pracitces	Perception	Culture/ Climate	Country	Company type
Domenech, Amoros, Perez-Gonzalvo, and Escriche (2011)	Implementation and effectiveness of the HACCP and pre-requisites in food establishments	X			X							Spain	Restaurants, hotels and cafeterias
Gomes-Neves, Cardoso, Araujo, and da Costa (2011)	Meat handlers training in Portugal: a survey on knowledge and practice							X[b]	X[b]			Portugal	Slaughter houses
Jacxsens et al. (2011)	Tools for the performance assessment and improvement of food safety management systems.	X				X						Belgium, the Netherlands, Spain and Greece	Food industry
Luning, Jacxsens, et al. (2011)	A concurrent diagnosis of microbiological food safety output and food safety management system performance: cases from meat processing industries	X				X						The Netherlands, Belgium and Spain	Meat processing companies
Rodriguez, Valero, Posada-Izquierdo, Carrasco, and Zurera (2011)	Evaluation of food handler practices and microbiological status of ready-to-eat foods in long-term care facilities in the Andalusia region of Spain	X							X[a]			Spain	Nursing homes

Reference	Title	Type of performance measurement										Country	Company type
		System and product related						People related					
		Microbiological analyses	Inspections	Internal audits	External audits	Diagnostic instrument	Other	Knowledge	Behavior/ pracitces	Perception	Culture/ Climate		
Lahou et al. (2012)	Microbiological performance of Food Safety Management System in a food service operation	X										Belgium	Restaurants and cafeterias
Oses et al. (2012a)	Food safety management system performance in the lamb chain.	X				X						Spain, the Netherlands and Belgium	Slaughter houses, Meat processing companies and butcheries
Oses et al. (2012b)	Microbial performance of Food Safety Management Systems implemented in the lamb production chain	X										Spain, the Netherlands and Belgium	Slaughter houses, Meat processing companies and butcheries
Sampers et al. (2012)	Semi-quantitative study to evaluate the performance of a HACCP-based food safety management system in Japanese milk processing plants					X						Belgium, Japan and the Netherlands	Dairy processing companies
Soon and Baines (2012)	Food safety training and evaluation of handwashing intention among fresh produce farm workers								X[b]			UK and Malaysia	Primary production
Wallace et al. (2012)	Re-thinking the HACCP team: an investigation into HACCP team knowledge and decision-making for successful HACCP development							X[b]	X[c]			UK	Multinational food producer

Reference	Title	Type of performance measurement									Culture/ Climate	Country	Company type
		System and product related						People related					
		Microbiological analyses	Inspections	Internal audits	External audits	Diagnostic instrument	Other	Knowledge	Behavior/ pracitces	Perception			
Domenech, Amoros, and Escriche (2013)	Effectiveness of prerequisites and the HACCP plan in the control of microbial contamination in ice cream and cheese companies	X			X							Spain	Dairy companies
Kafetzopoulos and Psomas (2013)	Measuring the effectiveness of the HACCP Food Safety Management System					X						Greece	Food industry
Kirezieva, Jacxsens, Uyttendaele, Van Boekel, and Luning (2013)	Assessment of the food safety management system in the fresh produce chain					X						The Netherlands and Belgium	Fresh produce
Kirezieva, Nanyunja, et al. (2013)	Context factors affecting design and operation of food safety management systems in the fresh produce chain					X						The Netherlands and Belgium	Primary production
Ko (2013)	The relationship among food safety knowledge, attitudes and self-reported HACCP practices in restaurant employees							X[b]	X[b]			Taiwan	Restaurants
Lee et al. (2013)	Does transformational leadership style influence employees' attitudes toward food safety practices?								X[b]		Organizational climate	US	Food service establishments
Luning et al. (2013)	Performance of safety management systems in Spanish food service establishments in view of their context characteristics					X						The Netherlands, Belgium and Spain	Student homes, hotels, restaurants

Reference	Title	Type of performance measurement: System and product related: Microbiological analyses	Inspections	Internal audits	External audits	Diagnostic instrument	Other	People related: Knowledge	Behavior/ pracitces	Perception	Culture/ Climate	Country	Company type
Masanganise, Matope, and Pfukenyi (2013)	A survey on auditing, quality assurance systems and legal frameworks in five selected slaughterhouses in Bulawayo, south-western Zimbabwe						X[e]					Zimbabwe	Slaughter houses
Opiyo, Wangoh, and Njage (2013)	Microbiological performance of dairy processing plants is influenced by scale production and the implemented Food Safety Management System: a case study	X										Kenya	Dairy processing companies
Osimani et al. (2013a)	Evaluation of the HACCP system in a university canteen: microbiological monitoring and internal auditing as verification tools	X		X								Italy	University canteen
Osimani, Aquilanti, Tavoletti, and Clementi (2013b)	Microbiological air monitoring of air quality in a university canteen: an 11-year report	X										Italy	University canteen
Rowell et al. (2013)	Influence of food safety training on grocery store employees' performance of food handling practices			X				X[b]	X[c]			US	Self service retail establishments

		Type of performance measurement											
		System and product related						People related					
Reference	**Title**	**Microbiological analyses**	**Inspections**	**Internal audits**	**External audits**	**Diagnostic instrument**	**Other**	**Knowledge**	**Behavior/ pracitces**	**Perception**	**Culture/ Climate**	**Country**	**Company type**
Soares et al. (2013)	Evaluation of food safety training on hygienic conditions in food establishments	X										Portugal	University canteens
Verhoef et al. (2013)	Reported behavior, knowledge and awareness toward the potential for norovirus transmission by food handlers in Dutch catering companies and institutional settings in relation to the prevalence of norovirus	X						X[b]	X[b]			The Netherlands	Catering
Djekic et al. (2014)	Quality management effects in certified Serbian companies producing food of animal origin					X						Serbia	Companies producing food of animal origin
Garayoa et al. (2014)	Catering services and HACCP: temperature assessment and surface hygiene control before and after audits and a specific training session	X					X[f]					Spain	Catering
Kafetzopoulos and Gotzamani (2014)	Critical factors, food quality management and organizational performance					X		X[b]	X[b]			Greece	Food industry
Le, Bazger, Hill, and Wilcock (2014)	Awareness and perceptions of food safety of artisan cheese makers in Southwestern Ontario: a qualitative study									X[d]		Canada	Artisanal cheese production

Reference	Title	Type of performance measurement: System and product related: Microbiological analyses	Inspections	Internal audits	External audits	Diagnostic instrument	Other	People related: Knowledge	Behavior/ pracitces	Perception	Culture/ Climate	Country	Company type
Milios, Drosinos, and Zoiopoulos (2014)	Food Safety Management System validation and verification in meat industry: Carcass sampling methods for microbiological hygiene criteria - A review	X										EU and US	Meat industry
Onjong, Wangoh, and Njage (2014)	Semi-quantitative analysis of gaps in microbiological performance of fish processing sector implementing current Food Safety Management Systems: a case study	X				X						South Africa	Fish processing companies
Thi et al. (2014)	Evaluation of the microbiological safety and quality of Vietnamese Pangasius hypophthalmus during processing by a microbial assessment scheme in combination with a self-assessment questionnaire	X				X						Vietnam	Pangasius processing companies
Toth and Bittsanszky (2014)	A comparison of hygiene standards of serving and cooking kitchens in schools in Hungary			X								Hungary	School kitchens
Abushelaibi et al. (2015)	Evaluation of the effect of person-in-charge (PIC) program on knowledge and practice change of food handlers in Dubai							X[b]	X[c]			Dubai	Food service establishments

Reference	Title	Type of performance measurement										Country	Company type
		System and product related						People related					
		Microbiological analyses	Inspections	Internal audits	External audits	Diagnostic instrument	Other	Knowledge	Behavior/ pracitces	Perception	Culture/ Climate		
Cukur, Demirbas, Cukur, Dayan, and Uzun (2015)	Evaluation of Attitudes and Behaviors on Food Safety and Quality Management Systems of Firm Owners in Olive Oil Enterprises: The Case Study of Mugla Province-Turkey							X[b]	X[b]			Turkey	Olive Oil production
da Cunha, Braga, Passos, Stedefeldt, and de Rosso (2015)	The existence of optimistic bias about foodborne disease by food handlers and its association with training participation and food safety performance							X[b]	X[b]	X[b]		Brazil	Food service establishments
da Cunha, Cipullo, Stedefeldt, and de Rosso (2015)	Food safety knowledge and training participation are associated with lower stress and anxiety levels of Brazilian food handlers							X[b]	X[b]	X[b]		Brazil	Food service establishments
Faour-Klingbeil et al. (2015)	Investigating a link of two different types of food business management to the food safety knowledge, attitudes and practices of food handlers in Beirut, Lebanon							X[b]	X[b]			Lebanon	SME's foodservice establishments
Harris, Murphy, DiPietro, and Rivera (2015)	Food safety inspections results: A comparison of ethnic-operated restaurants to non-ethnic-operated restaurants		X									US	Restaurants
Jacxsens et al. (2015)	Measuring microbial food safety output and comparing self-checking systems of food business operators in Belgium					X						Belgium	Food processing companies

		Type of performance measurement											
		System and product related						People related					
Reference	**Title**	**Microbiological analyses**	**Inspections**	**Internal audits**	**External audits**	**Diagnostic instrument**	**Other**	**Knowledge**	**Behavior/ pracitces**	**Perception**	**Culture/ Climate**	**Country**	**Company type**
Kirezieva et al. (2015)	Exploring the influence of context on food safety management: Case studies of leafy greens production in Europe					X						Europe	Leafy greens production
Kussaga, Luning, Tiisekwa, and Jacxsens (2015)	Current performance of food safety management systems of dairy processing companies in Tanzania	X				X						Tanzania	Dairy processing companies
Lahou, Jacxsens, Verbunt, and Uyttendaele (2015)	Evaluation of the food safety management system in a hospital food service operation toward Listeria monocytogenes	X				X						Belgium	Hospital food service operations
Luning et al. (2015)	Performance assessment of food safety management systems in animal-based food companies in view of their context characteristics: A European study					X						Europe	Animal-based food companies
McPhee-Knowles (2015)	Growing Food Safety from the Bottom Up: An Agent-Based Model of Food Safety Inspections		X									NA	Food industry
Nanyunja et al. (2015)	Assessing the Status of Food Safety Management Systems for Fresh Produce Production in East Africa: Evidence from Certified Green Bean Farms in Kenya and Noncertified Hot Pepper Farms in Uganda					X						Uganda and Kenya	Green Bean Farms and Hot Pepper Farms

Reference	Title	Type of performance measurement										Country	Company type
		System and product related						People related					
		Microbiological analyses	Inspections	Internal audits	External audits	Diagnostic instrument	Other	Knowledge	Behavior/ pracitces	Perception	Culture/ Climate		
Osimani, Aquilanti, and Clementi (2015)	Evaluation of HACCP System Implementation on the Quality of Mixed Fresh-Cut Salad Prepared in a University Canteen: A Case Study	X										Italy	University Canteen
Psomas and Kafetzopoulos (2015)	HACCP effectiveness between ISO 22000 certified and non-certified dairy companies					X						Greece	Dairy companies
Ramalho, de Moura, and Cunha (2015)	Why do small business butcher shops fail to fully implement HACCP?		X					X[b]	X[b]			Portugal	Small butcher shops
Toropilova and Bystricky (2015)	Why HACCP might sometimes become weak or even fail					X						Slovakia	Food processing industry
Castro-Ibanez et al. (2016)	Food safety management system (FSMS) adjusted to the characteristics of the leafy greens production chain context in Spain					X						Spain	Leafy greens production
Djekic et al. (2016)	Improving the confectionery industry supply chain through second party audits				X							Serbia	Confectionery industry
Dzingirayi and Korsten (2016)	Assessment of Primary Production of Horticultural Safety Management Systems of Mushroom Farms in South Africa					X						South Africa	Fresh produce: mushroom farming
Guchait, Neal, and Simons (2016)	Reducing food safety errors in the United States: Leader behavioral integrity for food safety, error reporting, and error management								X[b]			US	Food service establishments

Reference	Title	Type of performance measurement: System and product related: Microbiological analyses	Inspections	Internal audits	External audits	Diagnostic instrument	Other	People related: Knowledge	Behavior/ pracitces	Perception	Culture/ Climate	Country	Company type
Kirezieva, Bijman, Jacxsens, and Luning (2016)	The role of cooperatives in food safety management of fresh produce chains: Case studies in four strawberry cooperatives					X						Belgium and the Netherlands	Strawberry cooperatives
Nyarugwe et al. (2016)	Determinants for conducting food safety culture research										Food safety culture	The Netherlands	Food industry
Ren, He, and Luning (2016)	A systematic assessment of quality assurance-based food safety management system of Chinese edible oil manufacturer in view of context characteristics					X						China	Edible oil manufacturing
Spink, Moyer, and Speier-Pero (2016)	Introducing the Food Fraud Initial Screening model (FFIS)						X					NA	Food industry
Trafialek, Zwolinski, and Kolanowski (2016)	Assessing hygiene practices during fish selling in retail stores		X									Poland	Fish selling retail stores
Tzamalis, Panagiotakos, and Drosinos (2016)	A 'best practice score' for the assessment of food quality and safety management systems in fresh-cut produce sector					X						Greece	micro, small and medium-sized enterprises (SMEs) of the fresh-cut produce sector

Reference	Title	Type of performance measurement										Country	Company type
		System and product related						People related					
		Microbiologi cal analyses	Inspections	Internal audits	External audits	Diagnostic instrument	Other	Knowledge	Behavior/ pracitces	Perception	Culture/ Climate		
Zwietering, Jacxsens, Membre, Nauta, and Peterz (2016)	Relevance of microbial finished product testing in food safety management	X										Europe	Canned food, chocolate and cooked ham production
Dzwolak (2017)	Assessment of food allergen management in small food facilities			X		X						Poland	Small food production facilities
Henderson, LeMaster, Shepherd, and Dunn (2017)	Food Safety Program Performance Assessment in Tennessee, 2003-2011		X									US	Food service establishments
Njage et al. (2017)	Microbial Performance of Food Safety Control and Assurance Activities in a Fresh Produce Processing Sector Measured Using a Microbial Assessment Scheme and Statistical Modeling	X										Kenya	Fresh produce processing and export companies
Rossi et al. (2017)	Food safety knowledge, optimistic bias and risk perception among food handlers in institutional food services							X[b]		X[b]		Brazil	Institutional food services
Xiong, Liu, Chen, and Zheng (2017)	Performance assessment of food safety management system in the pork slaughter plants of China					X						China	Pork slaughter plants

a Evaluated through checklist.; b Evaluated through survey.; c Evaluated through observation.; d Evaluated through interview.; e Internal audits, external audits, quality management system and legal framework were evaluated through survey assessing perceptions of employees concerning effectiveness of these systems. ; f Evaluation of temperature. ; NA: Not Applicable

Appendix 1.B: Method for literature review (scientific publications from 2009 till June 2017) related to performance measurement of FSMS. Search engine used: Web of Science

Search terms	Total number of references	Relevant references	Libraries
'Food safety management system' + 'Performance assessment'	56	28	Web of Science Relevant references via: - IngentaConnect Journals (1) - Elsevier ScienceDirect (16) - ProQuest Central New Platform (6) - Allen Press Miscellaneous (2) - Contact with Contact with author (2) - Wiley Online library (1)
'Food safety management system' + 'Performance assessment'	21	3	Web of Science Overlap (2) Relevant references via: - Elsevier ScienceDirect (1)
'Food safety management system' + 'Performance measurement'	12	2	Web of Science Overlap (2)
'Food safety management system' + 'Assessment'	229	33	Web of Science Overlap (26) Relevant references via: - Elsevier ScienceDirect (6) - DOAJ Directory (1) - Contact with author (2)
'Food safety management system' + 'Evaluation'	128	8	Web of Science Overlap (4) Relevante referentie via: - ProQuest Central New Platform (1) - Elsevier ScienceDirect (2) - Contact with author (1)
'Food safety management system' + 'Measurement'	34	2	Web of Science Overlap (2)
'Food safety performance' + 'Inspection*'	119	7	Web of Science Overlap (2) Relevante referentie via: - PubMed Central (1) - ProQuest Central New Platform (1) - Elsevier ScienceDirect (3) -
'Food safety performance' + 'Audit*'	18	6	Web of Science Overlap (5) Relevante referentie via: - ProQuest Central New Platform (1)

Search terms	Total number of references	Relevant references	Libraries
‘Food safety performance’ + ‘Certificat*’	35	7	Web of Science Overlap (5) Relevante referentie via: - Allen Press Miscellaneous (1) - EBSCOhost Business Source Premier (1)
‘Food safety performance’ + ‘Observation*’	40	3	Web of Science Overlap (1) Relevante referentie via: - Elsevier ScienceDirect (2)
‘Food safety performance’ + ‘Knowledge’	136	12	Web of Science Overlap (7) Relevante referentie via: - Elsevier ScienceDirect (5)
‘Food safety performance’ + ‘Behavior’	124	9	Web of Science Overlap (6) Relevant references via: - Elsevier ScienceDirect (2) - ProQuest Central New Platform (1)
‘HACCP’ + ‘Effectiveness’	50	14	Web of Science Overlap (6) Relevant references via: - Elsevier ScienceDirect (5) - ProQuest Central New Platform (2) - Mary Ann Liebert Publishers Journals (1)
Supplemental to literature review	/	6	Web of Science - Elsevier ScienceDirect (6)

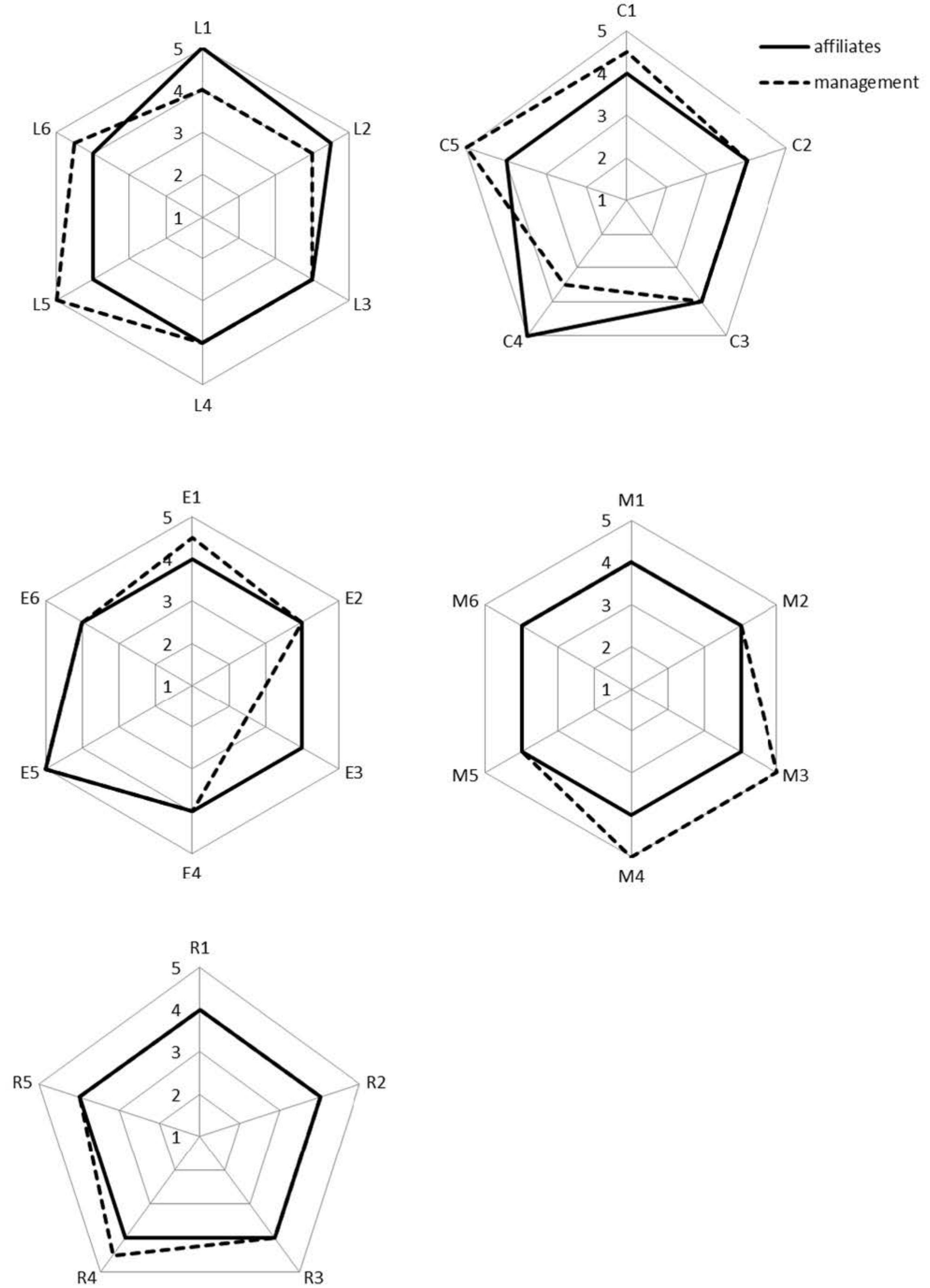
Appendix 1.C: Method for literature review (scientific publications between 2009 till June 2017) concerning food safety problems originating from food handler behavior/practices. Search engine used: Web of Science

Search terms	Total number of references	Relevant references	Search engine / Library
'Food handler associated' + 'safety problems'	4	0	Web of Science
'Food handler associated' + 'quality problems'	1	0	Web of Science
'Food handler associated' + 'hygiene problems'	7	0	Web of Science
'Food handler related + 'safety problems'	7	0	Web of Science
'Food handler related + 'quality problems'	2	0	Web of Science
'Food handler related + 'hygiene problems'	7	0	Web of Science
'Process related' + 'food safety problems'	97	0	Web of Science
'Process related' + 'food quality problems'	143	0	Web of Science
'Process related' + 'food hygiene problems'	15	0	Web of Science
'Process related' + 'food borne outbreaks'	23	0	Web of Science
'Process related' + 'Chemical problems' + 'Food industry'	37	0	Web of Science
'Acrylamide' + 'Food handler'	5	2	Web of Science Relevant references via: - Elsevier ScienceDirect (1) - ProQuest Central New Platform (1)
'MCPD' OR 'Monocholoropropanediol' + 'Food handler'	0	0	Web of Science
'Furan' + 'Food handler'	0	0	Web of Science
'Foodborne illness' + 'Food handler'	87	14	Web of Science Relevant references via: - ProQuest Central New Platform (6) - J-STAGE Free (1) - PubMed Central (4) - Allen Press Miscellaneous (1) - Springer Standard Collection (1) - Journals@OvidComplete (1)
'Foodborne illness' + 'Food worker'	64	12	Web of Science Overlap (7) Relevant references via: - ProQuest Central New Platform (4) - Mary Ann Liebert Publishers Journals (1)

Search terms	Total number of references	Relevant references	Search engine / Library
'Foodborne disease' + 'Food handler'	130	16	Web of Science Overlap (7) Relevant references via: - Springer Standard Collection (1) - ProQuest Central New Platform (6) - Elsevier ScienceDirect (1) - Oxford University Press Journals Current (1)
'Foodborne disease' + 'Food worker'	93	9	Web of Science Overlap (6) Relevant references via: - Elsevier ScienceDirect (3)
'Foodborne outbreak' + 'Food handler'	128	25	Web of Science Overlap (23) Relevant references via: - Springer standard Collection (1) - Mary Ann Liebert Publishers Journals (1)
'Foodborne outbreak' + 'Food worker'	96	16	Web of Science Overlap (16)
'Foodborne outbreak' + 'Food company'	39	4	Overlap (2) Web of Science Relevante referentie via: - Highwire Press Free (1) - Springer Standard Collection (1)
'Allergens'+ 'food handler'	16	1	Web of Science Relevant references via: - Elsevier ScienceDirect (1)
'Food allergens' + 'food worker'	57	2	Web of Science Relevant referentces via: - ProQuest Central New Platform (1) - PubMed Central (1)
'Food allergens' +'cross contamination'	58	1	Web of Science Relevant referentces via: - Wiley Online Library (1)

Appendix 2.A: Web diagrams with the median of the responses of butcher shop employees and management for the food safety climate indicators (pilot study chapter 2).

Web diagrams with the median of the responses (Likert answer scale 1→ 5) of the management (n=6) and the employees of affiliates (n=42) for the different indicators of the food safety climate self-assessment tool. L1-L6 for component leadership, C1-C5 for component communication, E1-E6 for component commitment, M1-M6 for component resources and R1-R5 for component risk awareness.



Appendix 3.A: FSMS Diagnostic instrument (Luning, Marcelis, et al., 2011), abbreviations of Figure 3.1 indicators

A: product/process related contextual factors		Meas-equip	measuring equipment to monitor process/ product status
Risk-mat	risk of raw materials	Cal-prog	calibration program for measuring and analytical equipment
Risk-prod	risk of product(s) (groups)	Sampl-des	sampling design (for microbial assessment) and measuring plan
Contr-pac	safety contribution of the packaging concept	Cor-act	corrective actions
Interv-step	extent of intervention steps	**D: operation of control activities**	
Proc-change	production process changes	Avail-proc	actual availability of procedures
Prod-des	rate of product/process design changes	Compl-proc	actual compliance to procedures
B: organizational/chain related contextual factors		Hyg-perf	actual hygienic performance of equipment and facilities
Tech-staf	technological staff	Cool-cap	actual cooling capacity
Var-work	variability of workforce composition	Anal-pef	actual performance of analytical equipment
Oper-comp	operator competences	**E: assurance activities**	
Man-commit	management commitment	Stake-req	translation of stakeholder requirements into own FSMS requirements
Empl-involv	employee involvement	Info-use	the systematic use of feedback information tomodify FSMS
Form	formalisation	Val-pre	validation of preventive measures
Info-syst	information systems	Val-mon	validation of monitoring systems
Safe-contr	safety contribution in chain	Ver-people	verification of people related performance
Supl-rel	supplier relationships	Ver-equip	verification of equipment and methods related performance
Stake-req	requirements of stakeholders	Doc-sys	Documentation system
C: design of control activities		Rec-sys	record keeping system
Hyg-des	hygienic design of equipment and facilities	**F: system output**	
Cool-fac	cooling facilities	FSMS-eval	FSMS evaluation
San-prog	sanitation programs	Ser-rem	seriousness of remarks of the FSMS evaluation
Pers-req	personal hygiene requirements	Micro-compl	microbiological food safety complaints of customers
Mat-contr	raw material control	Hyg-compl	hygiene related complaints by customers
Prod-meas	product specific preventive measures	Prod-sampl	product sampling to confirm microbiological performance
Main-prog	maintenance and calibration program for (intervention) equipment	Judg-crit	judgement criteria to interpret microbiological results
CCP-anal	analysis of CCP/CPs	Non-conf	hygiene and pathogen non conformities
Stand-tool	standards and tolerances design		
Anal-meth	analytical methods to assess pathogens		

Appendix 3.B: Example of one of the FSMS-DI indicators to assess the level of an organization's control activities (FSMS-Diagnostic instrument, Luning, Marcelis, et al., 2011)

Indicator Cool-Fac: At which level would you place the **cooling facilities** relevant for your (representative) production unit?

Adequate cooling facilities better maintain strict temperature conditions to prevent growth of micro organisms and pathogens, which will positively contribute to food safety			
Level 0	Level 1	Level 2	Level 3
Cooling facilities not used in production	• domestic/general cooling facilities • principal cooling capacity not known, no testing product temperature	• industrial cooling facilities • information about principal cooling capacity from suppliers, no testing of product temperature for different circumstances	• industrial cooling facilities specifically adapted for companies' specific food production circumstances • capacity tested by temperature check of environment and products, for different circumstances

Supporting information to differentiate levels 2 and 3
- When capacity of cooling facilities known then in situation 2 or 3
- Crucial for 3 is that cooling facilities are adapted (modified) and tested for your production circumstances, and actual product temperature checked for different circumstances

Information for pop-ups:
Cooling facilities may be room cooling facilities/equipment, refrigerators used in production zones, cooling zones, storage, fast cooling areas, etc.
Cooling capacity: a measure of the rate at which a system will transfer heat energy, normally expressed in tons. A refrigeration system of 1-ton capacity is theoretically capable of freezing 1 ton of water in 24 hours.
Temperature Check refers to direct measurement of the temperature of environment and of the interior of the product. It is good practice to use several probe thermometers in various locations to obtain an accurate temperature reading. In controlling a cooling facility, the most important temperature is that of the produce, not the air.

Appendix 3.C: Food safety climate self-assessment survey used in chapter 3

Survey food safety climate

This survey investigates the food safety climate in your organization. Responses are anonymous and will be treated anonymously.

Clarification:

Operators: *clarification of term 'Operators' depending on farm butchery / affiliated butcher shop structure*
Leaders: *clarification of term 'Leaders' depending on farm butchery / affiliated butcher shop structure*

I am: *multiple choice question depending on farm butchery / affiliated butcher shop structure asking for function of respondent within the organization*

Please read each of the following statements about food hygiene and safety practices in your organization and indicate whether you: strongly disagree (1), disagree (2), not agree nor disagree (3), agree (4) or strongly agree (5).

	LEADERSHIP	Strongly disagree	Disagree	Not agree nor disagree	Agree	Strongly agree
L1	In my organization, the leaders set **clear objectives** concerning hygiene and food safety.	1	2	3	4	5
L2	In my organization, the leaders are clear about the **expectations** concerning hygiene and food safety **towards operators**.	1	2	3	4	5
L3	In my organization, the leaders are able to **motivate** their operators to work in a hygienic and food safe way.	1	2	3	4	5
L4	In my organization, the leaders **listen to operators**, if they have remarks or comments concerning hygiene and food safety.	1	2	3	4	5
L5	In my organization, hygiene and food safety issues are addressed **in a constructive and respectful way** by the leaders.	1	2	3	4	5
L6	In my organization, the leaders strive for a **continuous improvement** of hygiene and food safety.					

	COMMUNICATION	Strongly disagree	Disagree	Not agree nor disagree	Agree	Strongly agree
C1	In my organization, the **leaders communicate regularly** with the operators about hygiene and food safety.	1	2	3	4	5
C2	In my organization, the **leaders communicate in a clear way** with the operators about hygiene and food safety.	1	2	3	4	5

C3	In my organization, it is possible for the **operators to communicate** about hygiene and food safety **with the leaders**.	1	2	3	4	5
C4	In my organization, the importance of hygiene and food safety is **permanently present** by means of , for example, posters, signs and/or icons related to hygiene and food safety.	1	2	3	4	5
C5	I can **discuss** problems concerning hygiene and food safety **with colleagues** in my organization.	1	2	3	4	5

	COMMITMENT	**Strongly disagree**	**Disagree**	**Not agree nor disagree**	**Agree**	**Strongly agree**
E1	In my organization, the leaders clearly consider hygiene and food safety to be of **great importance**.	1	2	3	4	5
E2	My colleagues are **convinced of the importance** of hygiene and food safety for the organization.	1	2	3	4	5
E3	In my organization, working in a hygienic and food safe way is **recognized and rewarded**	1	2	3	4	5
E4	In my organization, the leaders **set a good example** concerning hygiene and food safety.	1	2	3	4	5
E5	In my organization, the leaders **act quickly** to correct problems/issues that affect hygiene and food safety.	1	2	3	4	5
E6	In my organization, operators are **actively involved** by the leaders in hygiene and food safety related matters.	1	2	3	4	5

	RESOURCES	**Strongly disagree**	**Disagree**	**Not agree nor disagree**	**Agree**	**Strongly agree**
M1	In my organization, operators get **sufficient time** to work in a hygienic and food safe way	1	2	3	4	5
M2	In my organization, **sufficient staff** is available to follow up hygiene and food safety.	1	2	3	4	5
M3	In my organization, the **necessary infrastructure** (e.g. good work space, good equipment...) is available to be able to work in a hygienic and food safe way.	1	2	3	4	5

M4	In my organization, **sufficient financial resources** are provided to support hygiene and food safety (e.g. lab analyses, external consultants, extra cleaning, purchase equipment…).	1	2	3	4	5
M5	In my organization, **sufficient education and training** related to hygiene and food safety is given.	1	2	3	4	5
M6	In my organization, **good procedures and instructions** concerning hygiene and food safety are in place.	1	2	3	4	5
	RISK AWARENESS	**Strongly disagree**	**Disagree**	**Not agree nor disagree**	**Agree**	**Strongly agree**
R1	In my organization, the risks related to hygiene and food safety **are known**.	1	2	3	4	5
R2	In my organization, the risks related to hygiene and food safety **are under control**.	1	2	3	4	5
R3	My colleagues are **alert and attentive** to potential problems and risks related to hygiene and food safety.	1	2	3	4	5
R4	In my organization, the **leaders have a realistic picture** of the potential problems and risks related to hygiene and food safety.	1	2	3	4	5
R5	In my organization, the **operators have a realistic picture** of the potential problems and risks related to hygiene and food safety.	1	2	3	4	5

Thank you for your cooperation!

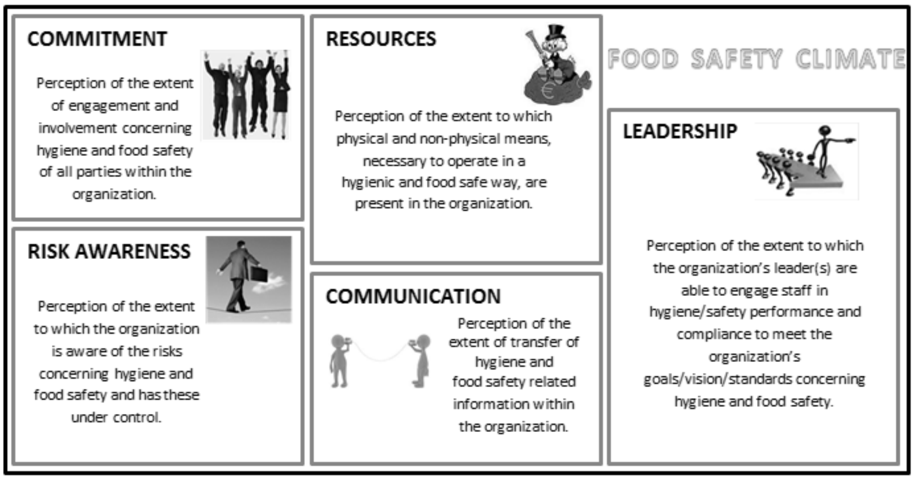
Appendix 4.A: Complete self-assessment survey used in chapter 4

Dear,

The Department of Food Safety and Food Quality from the Faculty of Bioscience Engineering (Ghent University) in collaboration with Department of Personnel Management, Work and Organizational Psychology, Faculty of Psychology and Educational Sciences (Ghent University)is currently conducting research dealing with food safety climate in the food chain. Focus in the last decades was mainly on development and implementation of food safety management systems such as self-checking, BRC and IFS in food companies.

Even if a company has a well-elaborated and 'fit for purpose' food safety management system, still, a constantly high and stable level of food safety and hygiene of the end product cannot be guaranteed. In our research, we investigate how human behavior (co)determines the actual execution of procedures and decision-making. This behavior is, among others, influenced by the food safety climate, prevailing in the company.

Following definition was developed for food safety climate: "employees'(shared) perception of leadership, communication, commitment, resources and risk awareness concerning food safety and hygiene within their current work organization". As such, food safety climate consists of 5 components, as indicated on the figure below.



In order to evaluate the food safety climate in companies, a self-assessment survey was developed with 28 indicators. This survey was validated by experts and was already applied in several case studies in the meat processing and in the vegetable processing sector.

We would like to distribute our food safety climate survey on a larger scale in Belgian food processing companies through this online tool, to get an idea of the level of the food safety climate. We would like to ask the plant manager, quality responsible or production responsible of your company (1 survey per site) to fill out this questionnaire. This only takes 5 minutes and responses are anonymous. Results will be used, anonymously, in a scientific publication of Elien De Boeck and will be communicated through FEVIA. In case of questions or remarks you can contact us.

Thank you in advance.

Kind regards,

ir. Elien De Boeck, Prof. Liesbeth Jacxsens and Prof. Peter Vlerick

1.Introductory questions

1. I am currently
   - ◯ Plant manager
   - ◯ Quality responsible
   - ◯ Production responsible
   - ◯ Other: ____

2. Is your company part of a larger (inter)national company (multiple sites)?
   - ◯ Yes
   - ◯ No

3. Does your company have multiple sites in Belgium?
   - ◯ Yes
   - ◯ No

4. Total number of full-time equivalents (FTE) in your company:
   - ◯ 0
   - ◯ 1-4
   - ◯ 5-9
   - ◯ 10-19
   - ◯ 20-49
   - ◯ 50-99
   - ◯ 100 or more

5. To which production sector does your company/site belong? (multiple responses possible)
   - ◯ Processing of potatoes, vegetables and fruits
   - ◯ Confectionery and breakfast cereals
   - ◯ Industrial bread and banquet bakery
   - ◯ Margarine production
   - ◯ Trade in potatoes, vegetables and fruits
   - ◯ Production of natural foods and vegetarian preparations
   - ◯ Consumption ice industry
   - ◯ slaughterhouses and cutting plants
   - ◯ Meat processing sector
   - ◯ Fish processing
   - ◯ Dairy industry
   - ◯ Processing of ready-to-eat meals
   - ◯ Production of Deli-salads
   - ◯ Brewery
   - ◯ Coffee (roasting) and tea
   - ◯ Production of packaged water, soft drinks, juices and nectars
   - ◯ Food ingredients and additives
   - ◯ Other: ____

6. For which standards is your company currently certified? (multiple responses possible)
   - ◯ None
   - ◯ ISO 9001:2015
   - ◯ FSSC 22000
   - ◯ BRC Global Standard for Food Safety
   - ◯ BRC Global Standard for Storage and Distribution
   - ◯ BRC Global Standard for Packaging and Packaging Materials
   - ◯ BRC Global market
   - ◯ IFS Food
   - ◯ IFS Logistics
   - ◯ IFS Global market
   - ◯ GLOBALGAP
   - ◯ Belgian Autocontrol (AC)/ Self-checking
   - ◯ GMP Plus Feed Safety Assurance
   - ◯ GMP Plus Feed Responsibility Assurance
   - ◯ Other: ____

7. Does your company have a quality responsible?
   - ◯ Yes
   - ◯ No

8. Does your company have a quality department?
   - ◯ Yes
   - ◯ No

9. How many full-time equivalents (FTE) are currently working in the quality department?
   - ◯ 1-5
   - ◯ 6-10
   - ◯ 11-15
   - ◯ 16-20
   - ◯ more than 20
   - ◯ Not applicable

10. How many employees are doing the quality controls on the floor (e.g. monitoring CCPs, hygienograms, executing weight checks, follow up of temperatures, control at reception…)? (Remark: number of employees, not FTE)
    - ◯ 1-5
    - ◯ 6-10
    - ◯ 11-15
    - ◯ 16-20
    - ◯ more than 20

11. How much of their time do these employees spend normally on quality control per week (per employee)?
    ◯ less than one day/week
    ◯ one day/week
    ◯ 2 days/week
    ◯ 3 days/week
    ◯ 4 days/week
    ◯ more than 4 days/week

12. What is the yearly budget available for maintaining the quality management system (e.g. sampling, consultancy, audit costs, training of staff)?
    ◯ No budget
    ◯ 1000-5000 EUR
    ◯ 5000-10 000 EUR
    ◯ 10 000-25 000 EUR
    ◯ More than 25 000 EUR

13. What is the frequency of food safety and hygiene training for employees?
    ◯ None
    ◯ More than 1 training/year
    ◯ Yearly
    ◯ Less than 1 training/ year

2. Food safety climate questions

Clarification:
Operators: Employees working on the work floor
Leaders: Plant manager(s), quality manager(s), production manager(s)

Please read each of the following statements about food hygiene and safety practices in your organization and indicate whether you: strongly disagree (1), disagree (2), not agree nor disagree (3), agree (4) or strongly agree (5).

	LEADERSHIP	**Strongly disagree**	**Disagree**	**Not agree nor disagree**	**Agree**	**Strongly agree**
L1	In my organization, the leaders set **clear objectives** concerning hygiene and food safety.	1	2	3	4	5
L2	In my organization, the leaders are clear about the **expectations** concerning hygiene and food safety **towards operators**.	1	2	3	4	5
L3	In my organization, the leaders are able to **motivate** their operators to work in a hygienic and food safe way.	1	2	3	4	5
L4	In my organization, the leaders **listen to operators**, if they have remarks or comments concerning hygiene and food safety.	1	2	3	4	5
L5	In my organization, hygiene and food safety issues are addressed **in a constructive and respectful way** by the leaders.	1	2	3	4	5
L6	In my organization, the leaders strive for a **continuous improvement** of hygiene and food safety.					
	COMMUNICATION	**Strongly disagree**	**Disagree**	**Not agree nor disagree**	**Agree**	**Strongly agree**
C1	In my organization, the **leaders communicate regularly** with the operators about hygiene and food safety.	1	2	3	4	5
C2	In my organization, the **leaders communicate in a clear way** with the operators about hygiene and food safety.	1	2	3	4	5
C3	In my organization, it is possible for the **operators to communicate** about hygiene and food safety **with the leaders**.	1	2	3	4	5
C4	In my organization, the importance of hygiene and food safety is **permanently present** by means of , for example, posters, signs and/or icons related to hygiene and food safety.	1	2	3	4	5
C5	I can **discuss** problems concerning hygiene and food safety **with colleagues** in my organization.	1	2	3	4	5

	COMMITMENT	Strongly disagree	Disagree	Not agree nor disagree	Agree	Strongly agree
E1	In my organization, the leaders clearly consider hygiene and food safety to be of **great importance**.	1	2	3	4	5
E2	My colleagues are **convinced of the importance** of hygiene and food safety for the organization.	1	2	3	4	5
E3	In my organization, working in a hygienic and food safe way is **recognized and rewarded**	1	2	3	4	5
E4	In my organization, the leaders **set a good example** concerning hygiene and food safety.	1	2	3	4	5
E5	In my organization, the leaders **act quickly** to correct problems/issues that affect hygiene and food safety.	1	2	3	4	5
E6	In my organization, operators are **actively involved** by the leaders in hygiene and food safety related matters.	1	2	3	4	5
	RESOURCES	**Strongly disagree**	**Disagree**	**Not agree nor disagree**	**Agree**	**Strongly agree**
M1	In my organization, operators get **sufficient time** to work in a hygienic and food safe way	1	2	3	4	5
M2	In my organization, **sufficient staff** is available to follow up hygiene and food safety.	1	2	3	4	5
M3	In my organization, the **necessary infrastructure** (e.g. good work space, good equipment...) is available to be able to work in a hygienic and food safe way.	1	2	3	4	5
M4	In my organization, **sufficient financial resources** are provided to support hygiene and food safety (e.g. lab analyses, external consultants, extra cleaning, purchase equipment…).	1	2	3	4	5
M5	In my organization, **sufficient education and training** related to hygiene and food safety is given.	1	2	3	4	5
M6	In my organization, **good procedures and instructions** concerning hygiene and food safety are in place.	1	2	3	4	5
	RISK AWARENESS	**Strongly disagree**	**Disagree**	**Not agree nor disagree**	**Agree**	**Strongly agree**
R1	In my organization, the risks related to hygiene and food safety **are known**.	1	2	3	4	5

R2	In my organization, the risks related to hygiene and food safety **are under control**.	1	2	3	4	5
R3	My colleagues are **alert and attentive** to potential problems and risks related to hygiene and food safety.	1	2	3	4	5
R4	In my organization, the **leaders have a realistic picture** of the potential problems and risks related to hygiene and food safety.	1	2	3	4	5
R5	In my organization, the **operators have a realistic picture** of the potential problems and risks related to hygiene and food safety.	1	2	3	4	5

14. Do you have still suggestions or remarks related to this survey?

____

Thank you for your cooperation.

Appendix 5.A: Overview of the data processing for CCP5 (limit of 75°C) for the different restaurants and cafeterias

CCP5: **limit of 75 °C**	**Number of days measured**	**Number of data points**	**Number of non-conformities**	**Number of non-conformities (%)(percentage of total registered for specific location)**	**Mean temperature (°C)**	**Standard deviation (°C)**	**P50 (°C)**	**P75 (°C)**	**P90 (°C)**
Restaurant A	126	1464	29	1.98	81.11	3.74	80	82	87
Restaurant B	105	1609	0	0.00	86.58	4.68	86	89	92
Restaurant C	177	1733	88	5.08	85.11	6.69	86	89	91
Restaurant D	168	3144	80	2.55	82.56	3.62	83	85	87
Restaurant E	133	3051	9	0.29	82.45	4.59	82	86	89
Restaurant F	122	1473	50	3.39	83.50	4.83	84	86	89
Restaurant G	121	1414	10	0.71	85.69	3.34	87	88	89
Restaurant H	122	2328	41	1.76	85.08	4.30	86	88	90
Restaurant I	122	1773	81	4.57	80.52	4.30	81	83	84
Cafeteria A	112	428	0	0.00	80.21	2.10	80	80	83
Cafeteria B	122	244	0	0.00	83.50	1.38	83	84	85
Cafeteria C	151	428	0	0.00	86.83	3.13	87	89	90
Cafeteria D	105	628	35	5.57	79.65	2.37	80	81	82
Cafeteria E	122	483	13	2.69	79.61	1.99	80	80	81
Cafeteria F	149	392	1	0.26	86.04	2.30	86	87	88
Cafeteria G	*No regenerated products offered*								

Appendix 5.B: Overview of the data processing for CCP6 (temperatures frying equipment : maximum limit of 175°C) for the restaurants and 5.C: Overview of the data processing for CCP6 (temperatures bain-maries : minimum limit of 80°C) for the restaurants and cafeteria C

Appendix 5.B

CCP6 frying temperatures:	Number of days measured	Number of data points	Number of non-conformities	Number of non-conformities (%)(percentage of total registered for specific location)	Mean temperature (°C)	Standard deviation (°C)	P50 (°C)	P75 (°C)	P90 (°C)
Restaurant A	110	439	20	4.56	171.42	1.91	171	172	173
Restaurant B	105	142	120	84.51	176.02	0.90	176	176	177
Restaurant C	115	271	25	9.23	172.26	2.61	172	174	175
Restaurant D	168	955	482	50.47	175.35	1.94	176	177	178
Restaurant E	132	694	422	60.81	175.65	1.92	176	177	178
Restaurant F	120	367	2	0.54	170.57	1.70	170	172	173
Restaurant G	122	431	6	1.39	167.33	4.39	170	170	171
Restaurant H	112	303	296	97.69	176.15	0.45	176	176	177
Restaurant I	62	57	51	89.47	177.07	1.13	177	178	178

Appendix 5.C

CCP6 Bain-maries	Number of days measured	Number of data points	Number of non-conformities	Number of non-conformities (%)(percentage of total registered for specific location)	Mean temperature (°C)	Standard deviation (°C)	P50 (°C)	P75 (°C)	P90 (°C)
Restaurant A	110	401	3	0.75	91.18	4.00	91	94	97
Restaurant B	105	404	4	0.99	90.70	4.06	92	94	94
Restaurant C	115	230	0	0.00	88.71	2.10	89	90	91
Restaurant D	168	2686	19	0.71	86.13	3.71	86	89	91
Restaurant E	132	2027	51	2.52	86.93	4.00	87	89	91
Restaurant F	120	586	0	0.00	95.35	3.82	95	98	101
Restaurant G	122	936	65	6.94	85.58	3.57	86	88	89
Restaurant H	112	624	23	3.69	84.48	2.65	85	86	88
Restaurant I	62	31	0	0.00	80.90	0.91	81	82	82
Cafeteria C	152	215	0	0.00	85.26	1.16	85	85	85

Appendix 5.D, 5.E and 5.F: Overview of data processing for CCP7

Appendix 5.D: Overview of data processing for CCP7: temperatures of smoked salmon and raw meat spread, with upper limit of 4°C in the buffets (start and end of shift)

CCP7: 4 °C start shift	Number of days measured	Number of temperature measurements	Number of non-conformities			Number of non-conformities (%)			Mean temperature (°C)	Standard deviation	P50 (°C)	P75 (°C)	P90 (°C)
			Total	Smoked salmong	Meat spread	Total	Smoked salmon	Meat spread					
Restaurant A	115	92	11	7	4	11.96	7.61	4.35	3.40	0.99	3.4	3.9	4.7
Restaurant B	105	64	4	2	2	6.25	3.13	3.13	3.72	0.69	3.9	4.0	4.2
Restaurant C	*Not applicable*												
Restaurant D	168	18	4	2	2	22.22	11.11	11.11	3.76	0.94	3.9	3.9	5.1
Restaurant E	127	131	2	0	2	1.53	0.00	1.53	3.20	0.77	3.2	3.7	3.9
Restaurant F	112	122	1	1	0	0.82	0.82	0.00	1.95	1.13	2.1	2.4	3.3
Restaurant G	137	180	0	0	0	0.00	0.00	0.00	2.19	0.69	2.1	3.0	3.0
Restaurant H	121	84	15	9	6	17.86	10.71	7.14	4.09	0.54	4.0	4.2	4.9
Restaurant I	*Not applicable*												
Cafetaria A	109	130	0	0	0	0.00	0.00	0.00	2.51	0.48	2.4	3.0	3.1
Cafetaria B	122	121	0	0	0	0.00	0.00	0.00	3.35	0.32	3.3	3.7	3.8
Cafetaria C	152	161	1	0	1	0.62	0.00	0.62	3.81	0.41	3.9	4.0	4.1
Cafetaria D	105	98	0	0	0	0.00	0.00	0.00	2.39	0.28	2.3	2.6	2.7
Cafetaria E	118	122	0	0	0	0.00	0.00	0.00	2.63	0.41	2.7	3.0	3.1
Cafetaria F	153	217	1	1	0	0.46	0.46	0.00	2.29	0.51	2.1	2.4	3.1
Cafetaria G	154	143	33	24	9	23.08	16.78	6.29	3.64	1.42	3.6	4.2	5.4

Appendix 5.D continued

CCP7: 4 °C end shift	Number of days measured	Number of measurements		Number of non-conformities			Number of non-conformities (%)			Mean temperature (°C)	Standard deviation	P50 (°C)	P75 (°C)	P90 (°C)
		Temperature	Sold out	Total	Smoked salmon	Meat spread	Total	Smoked salmon	Meat spread					
Restaurant A	115	79	7	3	2	1	3.80	2.53	1.27	3.04	0.94	3.1	3.6	4.1
Restaurant B	105	47	18	27	15	12	57.45	31.91	25.53	4.93	1.32	4.6	5.9	6.8
Restaurant C	*Not applicable*													
Restaurant D	168	18	0	7	2	5	38.89	11.11	27.78	4.59	1.32	4.0	5.2	6.4
Restaurant E	127	130	0	8	0	8	6.15	0.00	6.15	3.44	0.81	3.4	3.7	4.0
Restaurant F	112	106	16	1	1	0	0.94	0.94	0.00	3.21	0.72	3.4	3.7	4.0
Restaurant G	137	175	2	1	0	1	0.57	0.00	0.57	2.65	0.86	2.4	3.5	3.8
Restaurant H	121	77	7	27	13	14	35.07	16.88	18.18	4.55	0.95	4.0	4.9	6.2
Restaurant I	*Not applicable*													
Cafetaria A	109	122	8	0	0	0	0.00	0.00	0.00	2.36	0.49	2.2	2.6	3.1
Cafetaria B	122	121	0	0	0	0	0.00	0.00	0.00	3.14	0.30	3.1	3.4	3.6
Cafetaria C	152	91	59	0	0	0	0.00	0.00	0.00	3.78	0.45	3.9	4.0	4.1
Cafetaria D	105	98	0	0	0	0	0.00	0.00	0.00	2.48	0.27	2.5	2.7	2.9
Cafetaria E	118	122	0	0	0	0	0.00	0.00	0.00	2.72	0.41	2.9	3.1	3.1
Cafetaria F	153	153	64	1	1	0	0.65	0.65	0.00	2.59	0.49	2.4	2.9	3.2
Cafetaria G	154	138	4	24	12	12	17.39	8.70	8.70	3.27	1.47	3.1	4.1	5.0

Appendix 5.E: Overview of data processing for CCP7: temperatures of chilled products (upper limit of 7°C) in buffets (start and end of shift)

CCP7: 7 °C start shift	Number of days measured	Number of temperature measurements	Number of non-conformities	Number of non-conformities (%)	Mean temperature (°C)	Standard deviation	P50 (°C)	P75 (°C)	P90 (°C)
Restaurant A	115	251	0	0.00	3.65	1.13	3.6	4.5	5.2
Restaurant B	105	244	0	0.00	4.12	1.23	4.0	4.9	5.7
Restaurant C	*Not applicable*								
Restaurant D	168	486	0	0.00	5.09	0.93	5.1	5.8	6.2
Restaurant E	127	250	1	0.40	3.75	1.12	3.7	4.2	5.0
Restaurant F	112	245	0	0.00	2.28	1.07	2.2	2.9	3.5
Restaurant G	137	229	0	0.00	2.36	0.64	2.3	3.0	3.1
Restaurant H	121	300	5	1.67	5.00	1.43	5.0	6.2	6.9
Restaurant I	122	648	0	0.00	2.91	0.34	3.0	3.1	3.3
Cafetaria A	109	195	0	0.00	3.59	0.99	3.4	4.3	5.0
Cafetaria B	122	242	0	0.00	3.37	0.43	3.3	3.7	4.0
Cafetaria C	152	263	0	0.00	3.80	0.40	3.9	4.0	4.1
Cafetaria D	105	190	0	0.00	2.42	0.29	2.3	2.6	2.9
Cafetaria E	118	227	0	0.00	2.69	0.52	2.8	2.9	3.1
Cafetaria F	153	240	0	0.00	2.41	0.53	2.2	2.4	3.1
Cafetaria G	154	319	4	1.25	4.63	1.59	4.7	5.9	6.6

Appendix 5.E continued

CCP7: 7 °C end shift	Number of days measured	Number of measurements Temperature	Sold out	Number of non-conformities	Number of non-conformities (%)	Mean temperature (°C)	Standard deviation	P50 (°C)	P75 (°C)	P90 (°C)
Restaurant A	115	223	12	1	0.45	3.28	1.22	3.1	4.2	4.7
Restaurant B	105	177	69	1	0.57	4.87	1.23	4.7	5.8	6.7
Restaurant C	*Not applicable*									
Restaurant D	168	471	15	3	0.64	5.50	1.15	5.6	6.5	6.8
Restaurant E	127	247	1	2	0.81	3.95	1.20	3.9	4.5	5.6
Restaurant F	112	240	5	0	0.00	3.50	0.98	3.3	4.1	4.8
Restaurant G	137	225	1	0	0.00	2.73	0.75	2.5	3.3	3.6
Restaurant H	121	266	28	54	20.30	5.39	1.96	4.5	7.2	8.2
Restaurant I	122	177	0	0	0.00	3.02	0.63	3.2	3.5	3.7
Cafetaria A	109	188	0	0	0.00	3.40	0.93	3.3	4.1	4.6
Cafetaria B	122	240	0	0	0.00	3.11	0.37	3.0	3.3	3.7
Cafetaria C	152	220	0	0	0.00	3.79	0.39	3.9	4.0	4.1
Cafetaria D	105	190	0	0	0.00	2.50	0.29	2.4	2.7	2.9
Cafetaria E	118	227	0	0	0.00	2.74	0.37	2.9	3.1	3.1
Cafetaria F	153	187	64	0	0.00	2.65	0.51	2.5	3.0	3.4
Cafetaria G	154	309	7	22	7.11	4.54	1.95	4.3	5.6	6.7

Appendix 5.F: Overview of data processing for CCP7: temperatures of hot meal components (minimum limit of 65°C) in buffets (start and end of shift)

CCP7: 65 °C start shift	Number of days measured	Number of Temperature measurements	Number of non-conformities	Number of non-conformities (%)	Mean temperature (°C)	Standard deviation	P50 (°C)	P75 (°C)	P90 (°C)
Restaurant A	115	439	0	0.00	80.61	4.39	80.0	83.3	87.0
Restaurant B	105	408	1	0.25	83.24	5.05	83.4	86.3	89.2
Restaurant C	117	581	36	6.20	83.80	8.58	86.0	89.0	92.0
Restaurant D	168	836	0	0.00	81.37	5.18	82.0	85.1	87.6
Restaurant E	127	633	0	0.00	82.43	5.04	81.7	85.6	89.4
Restaurant F	112	487	2	0.41	83.03	5.46	84.0	86.0	89.0
Restaurant G	137	504	0	0.00	85.62	3.90	87.0	88.0	90.0
Restaurant H	121	596	0	0.00	76.07	4.75	76.3	79.8	81.9
Restaurant I	122	605	17	2.81	79.13	5.11	80.0	82.0	84.0
Cafetaria A	109	215	0	0.00	80.51	1.86	79.9	80.1	82.6
Cafetaria B	122	125	0	0.00	83.71	1.43	83.6	84.1	85.7
Cafetaria C	152	302	0	0.00	86.34	3.11	87.4	89.2	90.2
Cafetaria D	105	209	0	0.00	79.61	1.87	79.9	80.3	81.2
Cafetaria E	118	236	0	0.00	79.62	2.30	79.8	80.1	81.2
Cafetaria F	153	300	0	0.00	86.13	2.57	86.6	87.5	88.7
Cafetaria G	154	152	0	0.00	84.68	3.41	85.0	86.8	88.9

Appendix 5.F continued

CCP7: 65 °C end shift	Number of days measured	Number of measurements		Number of non-conformities	Number of non-conformities (%)	Mean temperature (°C)	Standard deviation	P50 (°C)	P75 (°C)	P90 (°C)
		Temperature	Sold out							
Restaurant A	115	237	97	0	0.00	79.13	4.97	79.6	82.5	84.7
Restaurant B	105	191	221	0	0.00	78.42	4.71	79.6	81.2	83.0
Restaurant C	117	223	345	15	6.73	77.14	6.96	79.0	82.0	84.0
Restaurant D	168	787	49	1	0.13	76.89	4.95	76.9	80.3	83.0
Restaurant E	127	620	8	5	0.81	78.45	3.96	78.0	80.5	82.6
Restaurant F	112	373	114	0	0.00	81.53	4.29	82.0	85.0	86.0
Restaurant G	137	431	69	0	0.00	82.52	4.15	84.0	85.0	87.0
Restaurant H	121	454	133	1	0.22	73.26	4.72	73.3	77.3	79.2
Restaurant I	122	240	365	6	2.50	76.28	4.33	77.0	78.0	80.0
Cafetaria A	109	198	17	0	0.00	79.29	1.52	79.0	79.3	80.1
Cafetaria B	122	233	0	0	0.00	69.28	3.91	68.1	70.2	74.8
Cafetaria C	152	158	130	0	0.00	86.04	3.42	86.4	88.2	90.2
Cafetaria D	105	208	1	0	0.00	79.10	2.46	79.7	80.3	81.1
Cafetaria E	118	234	0	0	0.00	79.45	1.73	80.1	80.1	80.3
Cafetaria F	153	159	144	0	0.00	84.69	2.70	85.2	86.4	87.2
Cafetaria G	154	146	5	0	0.00	79.36	3.67	79.2	81.8	84.1

Appendix 5.G: Exception list for regeneration (CCP5 <75°C)

<u>Exception list for regeneration (CCP5): Products with regeneration temperature < 75°C</u>

Core temperature 58°C;

- Atlantic salmon steak (marinated)
- Grilled hoki (with basil)
- Cod back MSC
- Coalfish delight
- Coalfish filet
- Nordic duo salmon coalfish
- Atlantic salmon steak

NOT Salmon steak gratino

Crumble of cod

Cod with saffron sauce

Coalfish tapenade

Fish sticks cod MCC

Seacrunch cod

Hoki meunière

Core 60°C

- Ardennes roast → vaccum (20 x 60g)

  → steaming 96°C, 20min

Core 50°C

- Beefsteak defrosted (no fat) → freezer box 5 kg (40 - 45 x 110 - 130 g)

  → bake 200°C, 12min

- Beefsteak from freezer (no fat) → freezer box 5 kg (40 - 45 x 110 - 130 g)

  → bake 220°C, 14min

Appendix 6.A: Complete self-assessment survey used in Chapter 6

UNIVERSITEIT GENT

Ghent, 22 September 2014,

Dear Mr., Mrs.,

Company X is currently involved in a research study conducted by Ghent University. This study investigates the relationship between the employees of Company X and the food safety of the products manufactured by Company X. Company X has regularly collaborated with the University of Ghent in the past.

Enclosed with this letter, you can find a questionnaire that will be filled out by all the employees of Company X. Filling out the questionnaire will take approximately 20 minutes of your time. There are no right or wrong answers. Please try to answer as honestly as possible.

All the data will be processed strictly confidentially and your anonymity is guaranteed. You can send your filled out questionnaire directly to us using the enclosed stamped envelope.

We would like to thank you for your cooperation in this research! In case you are interested in the results of this study, you can contact us via the information mentioned below.

Yours sincerely,

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QUESTIONNAIRE FOOD SAFETY AND WELL-BEING

I. Please read these statements about the hygiene and food safety in your organization and indicate whether you: totally disagree (1), disagree (2), don't agree and don't disagree (3), agree (4) or totally agree (5). Please encircle only one option.

	Totally disagree	Disagree	Don't agree, don't disagree	Agree	Totally agree
1. In my organization, the leaders set **clear objectives** concerning hygiene and food safety.	1	2	3	4	5
2. In my organization, the leaders are **clear** about the **expectations** concerning hygiene and food safety **towards employees**.	1	2	3	4	5
3. In my organization, the leaders are able to **motivate** their employees to work in a hygienic and food safe way.	1	2	3	4	5
4. In my organization, the leaders **listen to** employees, if they have remarks or comments concerning hygiene and food safety.	1	2	3	4	5
5. In my organization, hygiene and food safety issues are addressed in a **constructive and respectful** way by the leaders.	1	2	3	4	5
6. In my organization, the leaders strive for a **continuous improvement** of hygiene and food safety.	1	2	3	4	5
7. In my organization, the **leaders communicate regularly** with the **operators** about hygiene and food safety.	1	2	3	4	5
8. In my organization, the **leaders communicate in a clear way** with the **operators** about hygiene and food safety.	1	2	3	4	5
9. In my organization, it is **possible** for the **operators** to communicate about hygiene and food safety **with the leaders**.	1	2	3	4	5
10. In my organization, the importance of hygiene and food safety is **permanently present** by means of, for example, posters, signs and/or icons related to hygiene and food safety.	1	2	3	4	5
11. I can discuss problems concerning hygiene and food safety with **colleagues** in my organization.	1	2	3	4	5
12. In my organization, the leaders clearly consider hygiene and food safety to be of **great importance**.	1	2	3	4	5
13. **My colleagues** are convinced of the **importance** of hygiene and food safety for the organization.	1	2	3	4	5
14. In my organization, working in a hygienic and food safe way is **recognized and rewarded**.	1	2	3	4	5

	Totally disagree	Disagree	Don't agree, don't disagree	Agree	Totally agree
15. In my organization, the leaders set a **good example** concerning hygiene and food safety.	1	2	3	4	5
16. In my organization, the leaders **act quickly** to correct problems/issues that affect hygiene and food safety.	1	2	3	4	5
17. In my organization, employees are **actively involved** by the leaders in hygiene and food safety related matters.	1	2	3	4	5
18. In my organization, employees get **sufficient time** to work in a hygienic and food safe way.	1	2	3	4	5

19. In my organization, **sufficient staff** is available to follow up hygiene and food safety.	1	2	3	4	5
20. In my organization, the **necessary infrastructure** (e.g. good work space, good equipment…) is available to be able to work in a hygienic and food safe way.	1	2	3	4	5
21. In my organization, **sufficient financial resources** are provided to support hygiene and food safety (e.g. lab analyses, external consultants, extra cleaning, purchase equipment…).	1	2	3	4	5
22. In my organization, **sufficient education and training** related to hygiene and food safety is given.	1	2	3	4	5
23. In my organization, **good procedures and instructions** concerning hygiene and food safety are in place.	1	2	3	4	5
24. In my organization, the risks related to hygiene and food safety are **known**.	1	2	3	4	5
25. In my organization, the risks related to hygiene and food safety are **under control.**	1	2	3	4	5
26. **My colleagues** are **alert and attentive** to potential problems and risks related to hygiene and food safety.	1	2	3	4	5
27. In my organization, the **leaders** have a **realistic picture** of the potential problems and risks related to hygiene and food safety.	1	2	3	4	5
28. In my organization, the **operators** have a **realistic picture** of the potential problems and risks related to hygiene and food safety.	1	2	3	4	5

II. The following statements relate more to <u>you</u> as an individual and not to the organization as a whole. Please read the statements and indicate whether you: totally disagree (1), disagree (2), don't agree and don't disagree (3), agree (4) or totally agree (5). Please encircle only one option.

	Totally disagree	Disagree	Don't agree, don't disagree	Agree	Totally agree
29. I know how to perform my job in a food safe and hygienic manner.	1	2	3	4	5
30. I know the instructions and procedures concerning hygiene and food safety which are important for my own job.	1	2	3	4	5
31. I know how to maintain or improve hygiene and food safety in my workplace.	1	2	3	4	5
32. I know how to reduce the risk of incidents concerning hygiene and food safety in my workplace.	1	2	3	4	5
33. I always carry out my job in a food safe and hygienic manner.	1	2	3	4	5
34. I follow all the **necessary** hygiene and food safety procedures, when I carry out my job.	1	2	3	4	5
35. I follow the **correct** hygiene and food safety procedures when I carry out my job.	1	2	3	4	5
36. I strive to work in a hygienic and food safe manner.	1	2	3	4	5
37. I promote a hygienic and food safe way of working in my workplace.	1	2	3	4	5
38. I put in extra effort to improve the hygiene and food safety of the workplace.	1	2	3	4	5
39. I help my colleagues to work in a hygienic and food safe way.	1	2	3	4	5
40. I voluntarily carry out tasks or activities that help to improve hygiene and food safety in the workplace.	1	2	3	4	5
41. I believe that workplace hygiene and food safety are important issues.	1	2	3	4	5
42. I feel that it is worthwhile to put in extra effort to maintain or improve hygiene and food safety.	1	2	3	4	5
43. I feel that it is important to maintain hygiene and food safety at all times.	1	2	3	4	5
44. I believe that it is important to reduce the risk of foodborne outbreaks.	1	2	3	4	5

III. To which extent do you agree with the following statements about <u>yourself</u>? It concerns the way you see yourself <u>in general</u>. Please read the statements and indicate whether you: totally disagree (1), disagree (2), don't agree and don't disagree (3), agree (4) or totally agree (5). Please encircle only one option.

	Totally disagree	Disagree	Don't agree, don't disagree	Agree	Totally agree
45. I am always well prepared.	1	2	3	4	5
46. I make plans and stick to them.	1	2	3	4	5
47. I pay attention to details.	1	2	3	4	5
48. I get chores done right away.	1	2	3	4	5
49. I cannot persevere in doing things for a long time.	1	2	3	4	5

IV. The following statements can be used by employees to describe their direct superior. If you don't have a superior, please assess yourself on the following items. If you have more than one superior, please think about the superior that you are most in contact with. Please read the statements and indicate whether you: totally disagree (1), disagree (2), don't agree and don't disagree (3), agree (4) or totally agree (5).

	Totally disagree	Disagree	Don't agree, don't disagree	Agree	Totally agree
50. My superior asks for feedback to improve his/her relationship with others.	1	2	3	4	5
51. My superior clearly states what he/she means.	1	2	3	4	5
52. The actions of my superior are in line with his/her beliefs.	1	2	3	4	5
53. My superior asks for ideas that challenge his/her beliefs.	1	2	3	4	5
54. My superior describes accurately the way that others view his/her abilities.	1	2	3	4	5
55. My superior admits mistakes when they occur.	1	2	3	4	5
56. My superior uses his/her beliefs to make decisions.	1	2	3	4	5
57. My superior listens carefully to different perspectives before taking a decision.	1	2	3	4	5

	Totally disagree	Disagree	Don't agree, don't disagree	Agree	Totally agree
58. My superior shows that he/she understands his/her own strengths and weaknesses.	1	2	3	4	5
59. My superior shares information with others.	1	2	3	4	5
60. My superior does not let others influence him/her to do things that are not in line with his/her beliefs.	1	2	3	4	5
61. My superior objectively analyzes relevant data before making a decision.	1	2	3	4	5
62. My superior is aware of the impact he/she has on others.	1	2	3	4	5
63. My superior expresses his/her ideas and thoughts clearly to others.	1	2	3	4	5
64. My superior lets his/her ethical norms affect his/her actions.	1	2	3	4	5
65. My superior encourages others to express opposing opinions.	1	2	3	4	5

V. The following statements concern how you experience your work and how it makes you feel. Please read the statements and indicate whether they are: Never (1), Rarely (2), Occasionally (3), Regularly (4), Often (5), Very often (6) or Always (7) applicable to you.

	Never	Rarely (a few times per year or less)	Occasionally (one time per month or less)	Regularly (a few times per month)	Often (one time per week)	Very often (a few times per week)	Always (daily)
66. I feel mentally exhausted by my job.	1	2	3	4	5	6	7
67. I question the utility of my job.	1	2	3	4	5	6	7
68. Working a full-time day is a heavy burden for me.	1	2	3	4	5	6	7
69. I know how to solve the problems at my job in a good way.	1	2	3	4	5	6	7
70. I feel burned out by my job.	1	2	3	4	5	6	7
71. I feel that I make a positive contribution to the operation of the organization with my job.	1	2	3	4	5	6	7
72. I notice that I am taking more distance from my job lately.	1	2	3	4	5	6	7

	Never	Rarely (a few times per year or less)	Occasionally (one time per month or less)	Regularly (a few times per month)	Often (one time per week)	Very often (a few times per week)	Always (daily)
73. I am not as enthusiastic about my job as I used to be.	1	2	3	4	5	6	7
74. I feel that I am good at my job.	1	2	3	4	5	6	7
75. When I finish something at work, this cheers me up.	1	2	3	4	5	6	7
76. At the end of the workday I feel empty.	1	2	3	4	5	6	7
77. I have achieved a lot of valuable things in my job.	1	2	3	4	5	6	7
78. I feel tired when I get up in the morning and a new workday lies ahead.	1	2	3	4	5	6	7
79. Currently, I am less proud of the results of my job.	1	2	3	4	5	6	7
80. At my job, I glow with confidence.	1	2	3	4	5	6	7
81. How often do you feel stressed because of your job?	1	2	3	4	5	6	7

VI. The following statements can be used to describe <u>yourself</u> <u>at work</u>. Please read the statements and indicate whether you: totally disagree (1), disagree (2), don't agree and don't disagree (3), agree (4) or totally agree (5). Please encircle only one option.

	Totally disagree	Disagree	Don't agree, don't disagree	Agree	Totally agree
82. I feel confident in representing my work area in meetings with management.	1	2	3	4	5
83. I feel confident contributing to discuss about the future of my company.	1	2	3	4	5
84. I feel confident presenting information to my colleagues.	1	2	3	4	5
85. If I should find myself in a jam at work, I could think of many ways to get out of it.	1	2	3	4	5
86. Right now I see myself at being pretty successful at work.	1	2	3	4	5

	Totally disagree	Disagree	Don't agree, don't disagree	Agree	Totally agree
87. I can think of many ways to reach my current work goals.	1	2	3	4	5
88. At this time, I am meeting the work goals that I have set for myself.	1	2	3	4	5
89. I can be "on my own" so to speak at work if I have to.	1	2	3	4	5
90. I usually take stressful things at work in stride.	1	2	3	4	5
91. I can get through difficult times at work because I've experienced difficulty before.	1	2	3	4	5
92. I always look on the bright side of things regarding my job.	1	2	3	4	5
93. I am optimistic about what will happen to me in the future as it pertains to work.	1	2	3	4	5

VII. The following statements concern your <u>current job</u> and the way you experience it. Please read the statements and indicate whether you: totally disagree (1), disagree (2), don't agree and don't disagree (3), agree (4) or totally agree (5). Please encircle only one option.

	Totally disagree	Disagree	Don't agree, don't disagree	Agree	Totally agree
94. I work with competent colleagues (people who know how to do their job).	1	2	3	4	5
95. The colleagues that I work with show interest in me as a person.	1	2	3	4	5
96. The colleagues that I work with are kind.	1	2	3	4	5
97. The colleagues that I work with are helpful with the execution of my job.	1	2	3	4	5
98. My superior is concerned about the wellbeing of his employees.	1	2	3	4	5
99. My superior listens to what I say.	1	2	3	4	5
100. My superior is helpful with the execution of my job.	1	2	3	4	5
101. My superior encourages working together.	1	2	3	4	5
102. My job obliges me to work very fast.	1	2	3	4	5

	Totally disagree	Disagree	Don't agree, don't disagree	Agree	Totally agree
103. My job obliges me to work very hard.	1	2	3	4	5
104. I have enough time to execute my job.	1	2	3	4	5
105. People do not impose an excessive amount of work on me.	1	2	3	4	5
106. At work, others do not make opposing demands of me.	1	2	3	4	5
107. My job regularly allows me to take my own decisions.	1	2	3	4	5
108. In my job I have little freedom to determine how I do my work.	1	2	3	4	5
109. I have a say in what happens at my job.	1	2	3	4	5

VIII. To enable better interpretation of our study results, we ask you a few personal questions and questions concerning your profession below. Please fill out what is missing or encircle the applicable number.

110. Which type of employment contract do you have at the company you are currently working for?
1 a permanent contract
2 a fixed-term contract
3 an agreement for temporary employment
4 other: (Which?)..

111. What is your gender?
1 Male
2 Female

112. What is your age?
1 20-29 years
2 30-39 years
3 40-49 years
4 50-59 years
5 60 years and above

113. How many years have you been working in your current job? .... years

114. How many years have you been working in the food sector? .... years

115. How often, on average per week, do you have personal contact with your direct superior?
.... times per week

116. Altogether, how much time, on average per week, do you have personal contact with your direct superior?
.... hours........................... minutes per week

117. Do you function as a leader within your organization?
1 Yes
2 No

118. How many hours do you work on average per week?
   1 fulltime
   2 part-time ≥ 50 %
   3 part-time < 50 %
   4 other:........................

119. What is your highest degree?
   1 primary school
   2 lower secondary education
   3 higher secondary education
   4 higher than secondary education, not university
   5 higher than secondary education, university

120. Do you work in shifts?
   1 Yes
   2 No

121. How many hours of training and/or education have you had in the past 12 months within your organization?
.... hours

This is the end of the questionnaire. Please check whether you have answered all the questions. Please put your filled out questionnaire in the enclosed envelope and send this to us via post.

A sincere thank you for your cooperation!

Key linking statements to variables for survey used in chapter 6

Variable	Subcomponents	Statement number(s) in survey
Food safety climate	-Leadership	1-6
	-Communication	7-11
	-Commitment	12-17
	-Resources	18-23
	-Risk awareness	24-28
Food safety knowledge		29-32
Food safety motivation		41-44
Food safety behavior	-Compliance	33-36
	-Participation	37-40
Conscientiousness		45-49
Authentic Leadership*		50-65
Burnout	-Exhaustion	66-70
	-Distance/Detachment	71-75
	-Inadequacy	76-80
Jobstress		81
Psycholocial capital*		82-93
Job characteristics*		94-109
Demographical and organizational characteristics		110-121

*used in other research

Curriculum vitae

Elien De Boeck was born on the 28th of February 1990 in Aalst, Belgium. She obtained her high school degree in Latin-Greek at Sint-Catharinacollege Geraardsbergen in 2008. In 2013 she graduated as a Master of Science in Bioscience Engineering: Food Science and Nutrition at the Faculty of Bioscience Engineering (Ghent University) with great honor. In September 2013, she started as a teaching assistant at the Department of Food Technology, Safety and Health (faculty of Bioscience-Engineering) under the supervision of Prof. dr.ir. Liesbeth Jacxsens. As an assistant, she was co-responsible for the lectures on quality and food safety management, and risk analysis in the agro-food chain and she guided several students with their master thesis. For her PhD research, she was supervised by Prof.dr.ir Liesbeth Jacxsens (promotor, Department of Food Technology, Safety and Health, Faculty of Bioscience Engineering), Prof. dr. Peter Vlerick (co-promotor, Department of Personnel Management, Work and Organizational Psychology, Faculty of Psychology and Educational Sciences) and Prof.dr.ir. Mieke Uyttendaele (co-promotor, Department of Food Technology, Safety and Health, Faculty of Bioscience Engineering). In her PhD research she is focusing on food safety management systems and food safety culture in food companies. She is also part of the food safety culture science group 'Salus', which is an international group of academics, active researchers and practitioners which stand for a scientific approach to food safety culture by developing and sharing food safety culture research, and disseminating and translating research into tools, guidance and advice to the food sector.

During her research she attended and participated in various national and international conferences and published in international peer reviewed journals.

Elien De Boeck werd geboren op 28 februari 1990 in Aalst, België. Ze behaalde haar secundaire school diploma 'Latijn-Grieks' in het Sint-Catharinacollege te Geraardsbergen in 2008. In 2013 studeerde ze af als Master in de bio-ingenieurswetenschappen: Levensmiddelenwetenschappen en voeding aan de faculteit bio-ingenieurswetenschappen (Universiteit Gent) met grote onderscheiding. In september 2013 startte ze als onderwijs assistent aan de vakgroep Levensmiddelentechnologie, voedselveiligheid en gezondheid (faculteit bio-ingenieurswetenschappen) onder de supervisie van Prof. dr.ir. Liesbeth Jacxsens. Als assistente was ze mede verantwoordelijk voor de lessen kwaliteitszorg en risico-analyse in de agro-voedselketen en begeleidde ze verschillende studenten met hun masterproef. Voor haar doctoraatsonderzoek werd ze begeleid door Prof.dr.ir Liesbeth Jacxsens (promotor, vakgroep Levensmiddelentechnologie, voedselveiligheid en gezondheid, faculteit bio-ingenieurswetenschappen), Prof. dr. Peter Vlerick (co-promotor, vakgroep personeelsbeleid-, arbeids- en organisatiepsychologie, faculteit psychologie en pedagogische wetenschappen) and Prof.dr.ir. Mieke Uyttendaele (co-promotor, Levensmiddelentechnologie, voedselveiligheid en gezondheid, faculteit bio-ingenieurswetenschappen). In haar doctoraatsonderzoek focust ze op voedselveiligheidssystemen en voedselveiligheidscultuur in voedingsbedrijven. Ze is ook lid van de voedselveiligheidscultuur wetenschapsgroep 'Salus'. Dit is een internationale groep van academici, actieve onderzoekers en deskundigen die zich inzetten voor een wetenschappelijke benadering van voedselveiligheidscultuur via het ontwikkelen en delen van onderzoek met betrekking tot voedselveiligheidscultuur, en het verspreiden en vertalen van dit onderzoek naar tools, begeleiding en advies voor de voedingsindustrie.

Gedurende haar onderzoek heeft ze deelgenomen aan verscheidene nationale en internationale conferenties en publiceerde zij in verschillende wetenschappelijke tijdschriften en praktijkbladen.

Publications in A1 peer-reviewed journals

De Boeck, E., Jacxsens, L., Mortier, A.V., & Vlerick, P. (2018). Quantitative study of food safety climate in Belgian food processing companies in view of their organizational characteristics. *Food Control, 88*, 15-27.

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De Boeck, E., Jacxsens, L., Bollaerts, M., & Vlerick, P. (2015). Food safety climate in food processing organizations: Development and validation of a self-assessment tool. *Trends in Food Science and Technology*, *46*, 242-251.

Wang, X., Lahou, E., **De Boeck, E**., Devlieghere, F., Geeraerd, A., Uyttendaele, M. (2015). Growth and inactivation of *Salmonella enterica* and *Listeria monocytogenes* in broth and validation in ground pork meat during simulated home storage abusive temperature and home pan-frying. *Frontiers in Microbiology* 6:1161. doi:10.3389/fmicb.2015.01161

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Extended abstracts of symposia

De Boeck, E. , Jacxsens, L., Mortier, A.V., Vlerick, P. (2017). Quantitative study of food safety climate in Belgian food processing companies in view of their organizational characteristics. Poster presentation. Presented at the 22nd Conference on Food Microbiology, Belgian Society for Food Microbiology (BSFM), September 21 – September 22, Brussels, Belgium

De Boeck, E., Mortier, A. V., Jacxsens, L., Dequidt, L., & Vlerick, P. (2017). Towards an extended food safety culture model : studying the moderating role of burnout and jobstress, the mediating role of food safety knowledge and motivation in the relation between food safety climate and food safety behavior . Oral presentation. Presented at the 2017 Annual meeting of the International Association for Food Protection (IAFP 2017), July 10 – July 12, Tampa, Florida.

De Boeck, E., Jacxsens, L., Dequidt, L., & Vlerick, P. (2016). Impact of food safety climate on food safety and hygiene output in two vegetable processing companies. Poster presentation. Presented at the 2016 European symposium on Food Safety, International Association for Food Protection (IAFP), May 11 – May 13, Athens, Greece.

Uyttendaele, M., **De Boeck, E**., & Jacxsens, L. (2016). Challenges in food safety as part of food security : lessons learnt on food safety in a globalized world. In C. N. Walpita, P. Sorgeloos, I. Karunasagar, & K. Ranaweera (Eds.), Procedia Food Science (Vol. 6, pp. 16–22). Presented at the International conference of Sabaragamuwa University of Sri Lanka 2015 (ICSUSL 2015): Challenges beyond food security, Amsterdam, The Netherlands: Elsevier Science.

De Boeck, E., Jacxsens, L., Goubert, H., Uyttendaele, M. (2016). Food safety management challenges in community driven initiatives to reduce food losses. Poster presentation. Presented at the 21st Conference on Food Microbiology, Belgian Society for Food Microbiology (BSFM), September 15 – September 16, Brussels, Belgium.

De Boeck, E., Jacxsens, L., Goubert, H., Uyttendaele, M. (2016). Food donations: who is guarding food safety. Poster presentation. Presented at the 21st Conference on Food Microbiology, Belgian Society for Food Microbiology (BSFM), September 15 – September 16, Brussels, Belgium.

De Boeck, E., Jacxsens, L., Goubert, H., Uyttendaele, M. (2016). Impact of food safety climate on food safety and hygiene output in vegetable processing companies. Poster presentation. Presented at the 21st Conference on Food Microbiology, Belgian Society for Food Microbiology (BSFM), September 15 – September 16, Brussels, Belgium.

De Boeck, E., Jacxsens, L., Bollaerts, M., & Vlerick, P. (2015). Food safety culture. Oral presentation. Presented at the 20th National symposium of Applied Biological Sciences (NSABS 2015), January 30, Louvain-La-Neuve, Belgium.

De Boeck, E., Jacxsens, L., Bollaerts, M., & Vlerick, P. (2015). Interplay between food safety climate, food safety management system and microbiological hygiene and safety: illustrated in farm butcheries and affiliated butcher shops. Oral presentation. Presented at the 2nd International conference on Food Safety and Regulatory Measures, August 17-August 19, Birmingham, UK.

De Boeck, E., Jacxsens, L., Bollaerts, M., & Vlerick, P. (2015). Interplay between food safety climate, food safety management system and microbiological output in farm butcheries and affiliated butcher shops. Poster presentation. Presented at the 2015 IAFP European symposium on Food Safety, International Association of Food Protection (IAFP), April 20- April 22, Cardiff, Wales, UK.

De Boeck, E., Jacxsens, L., Vlerick, P., & Uyttendaele, M. (2014). Development and validation of a Food Safety Climate assessment tool. Poster presentation. Presented at the IAFP European symposium on Food Safety 2014, International Association for Food Protection (IAFP), May 7 – May 9, Budapest, Hungary.

De Boeck, **E**., Jacxsens, L., & Vlerick, P. (2014). Is food safety climate impacting safety and quality?: case study of meat distribution. Poster presentation. Presented at the 19th Conference on Food Microbiology, Belgian Society for Food Microbiology (BSFM), September 18 – September 19, Brussels, Belgium.

Dissemination

De Boeck, E., Jacxsens, L.& Vlerick, P. (2017). Voedselveiligheidsklimaat in de Belgische voedselverwerkende industrie. *Food Science and Law*, 4, 135-140.

Jacxsens, L., Vlerick, P., **De Boeck, E**., Dequidt, L., & Mortier, A. (2016). Impact op klimaat voedselveiligheid: Universiteit Gent onderzoekt rol medewerker. *Voedingsmiddelentechnologie*, 2, 30–33.

Jacxsens, L., **De Boeck, E.**, De Vos, L., Goubert, H. Wat met voedselverliezen? Wettelijk kader en knelpunten bij voedseldonaties en community driven initatives. (2016). Speaker at Foodlabs at Boom, May 28, Watt site, Ghent, Belgium.

Jacxsens, L., Vlerick, P., **De Boeck, E.**, Dequidt, L., & Mortier, A. (2015). Impact op voedselveiligheidsklimaat: Universiteit Gent onderzoekt rol medewerker. *Voedingsmiddelentechnologie*, (2015/10), 23–25.

Doctoral schools program

Specialist courses

2014-2015: Erasmus Intensive Programme Predictive Modelling and Risk Assessment: Risk Assessment

2016-2017: Auditor/Lead Auditor Kwaliteitsmanagementsysteem ISO 9001:2015 (Amelior, center for ecxellence)

2016-2017: Interne auditor voedselveiligheid en HACCP (Amelior, center for excellence))

Personal skills training

2013-2014: Schrijven voor ingenieurs

2014-2015: Advanced Academic English: Writing Skills ((Bioscience) Engineering)

2016-2017: Project management

2016-2017: Facultaire workshop Peer assessment

Supervision of undergraduate students

AJ 2013-2014: *Michiel Bollaerts*
Voedselveiligheidscultuur in slagerijen

AJ 2014-2015: *Lisa Dequidt*
Invloed van het voedselveiligheidsklimaat op het gedrag van werknemers en op de uiteindelijke output in groenteverwerkende bedrijven

AJ 2015-2016: *Helena Goubert*
Voedselbank bewaakt de voedselveiligheid: zijn alle voedselresten welkom?

Lieselot De Vos
Hygiëne en kwaliteitszorg bij community driven initiatieven gericht op het verminderen van voedselverliezen

AJ 2016-2017: *Pauline Vanoverberghe*
Validatie en verificatie van het voedselveiligheidssysteem van de maaltijdvoorzieningen van Universiteit Gent

AJ 2017-2018: *Sara Kurban*
Assessing the impact of the simplified hazard analysis approach for certain small retail establishments